

4. Fish

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Draft

4-1 Bull Trout/Dolly Varden

4-1.1 Species Name

Salvelinus confluentus

Common Name: Bull trout

Bull trout are members of the *Salvelinus* genus and are taxonomically very similar to Dolly Varden (*Salvelinus malma*). In fact, bull trout were not widely recognized as a distinct species until 1978 (Cavender 1978). While it is difficult to distinguish between bull trout and Dolly Varden using morphometric techniques, it is possible to distinguish between the two using genetic techniques. The ranges for these two similar species overlap in Washington (Washington Fish and Wildlife 2000).

Initial coverage recommendation: Covered

4-1.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS (US FISH AND WILDLIFE)

Threatened (1998)

WASHINGTON FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

G3

NATURAL HERITAGE PROGRAM STATE RANK

S3

4-1.3 Range

Bull trout occur from the headwaters of the Yukon River in Alaska to the Klamath basin in Oregon (Dunham et. al 2003). While the southern range of bull trout was much broader during the last major ice age and extended as far south as the McCloud River (Cavendar 1978), the species currently occurs in numerous sub-basins in the interior

Columbia with their range extending into parts of Montana, Idaho (the Wood River) Nevada (the Jarbridge River), and Canada (Bond 1992). The U.S. Fish and Wildlife Service recognizes five distinct population segments within the coterminous United States: 1) Coastal-Puget Sound; 2) St. Mary-Belly River; 3) Klamath River; 4) Columbia River; and 5) Jarbridge River. Bull trout are widely distributed in the state of Washington (Appendix F) and the overall range is likely similar to the historical range (Washington Fish and Wildlife 2000). The state of Washington currently recognizes 80 bull trout /Dolly Varden stocks.

4-1.4 Habitat Use

ADULT

Bull trout may live to 15 years of age (Donald and Alger 1992) and exhibit resident, fluvial, adfluvial, and anadromous life history forms. Resident bull trout utilize small headwater streams for all of their life-stages and may reside within a few hundred meters of where they were born. Resident fish tend to be small as adults (15 to 30 centimeters in length) and do not attain the greater lengths exhibited by other life history forms. Bull trout that exhibit the fluvial life history form typically spawn in small tributaries and, after a short period of rearing, individuals move into larger streams where most growth and maturation occurs. Similarly, adfluvial bull trout utilize small headwater streams for spawning and early rearing (1 to 3 years) but migrate to lakes for growth and maturation. Anadromous bull trout utilize small streams for spawning and rearing and then migrate to the more productive nearshore marine and estuarine wetland ecosystems for growth and maturation. The life history strategies exhibited by bull trout are very flexible and individual fish may not only adopt more than one strategy during the course of a lifetime, but they may alternate strategies from year to year.

Bull trout require cold, clean water and although they are generally absent when temperatures rise above 18° Celsius, they have been observed in lakes with temperatures up to 20° Celsius (Donald and Alger 1992). Increased stream temperatures are believed to negatively impact 11 of 34 subpopulations in the Coastal Puget Sound population segment (Department of Interior 1999).

SPAWNING/INCUBATION/EMERGENCE

Spawning migrations for fluvial, adfluvial, and anadromous bull trout may begin as early as April and during these migrations bull trout likely occur in nearly all of the ecosystems and habitats under consideration in this project. Spawning typically occurs in small headwater streams (Meehan and Bjornn 1991) and in some cases, the distance between foraging areas and spawning areas is known to exceed 160 kilometers (e.g., the Skagit River).

Bull trout are iteroparous (capable of spawning more than once) with spawning occurring in the late summer and fall in water temperatures between 5° and 9° Celsius. Similarly to other salmonids, bull trout prefer spawning in substrates consisting of clean loose gravel. Depending on the size of the individual, a female may deposit between 100 and 10,000 eggs (Meehan and Bjornn 1991). Egg development is dependent on temperature and as

much as six months may pass between spawning and emergence (Meehan and Bjornn 1991).

REARING/OUTMIGRATION

Bull trout typically rear in their natal streams for two to four years, although resident fish may remain in these streams for their entire lives. Young-of-the-year bull trout utilize low velocity habitats such as side channels and the lateral margins of streams (Wydoski and Whitney 2003), feeding primarily on aquatic invertebrates and fish eggs. While the resident form of this species may subsist entirely on insects, migratory forms become increasingly piscivorous with increasing size.

Fluvial and adfluvial bull trout typically migrate out of their natal streams between 2 and 4 years of age and occupy a wide range of freshwater habitat types including small, high gradient and high elevation streams; large, low gradient and low elevation streams; and the littoral zones of lakes. Bull trout diet in lakes is highly variable and may consist of invertebrates (e.g., chironomidae, ephemeroptera, trichoptera, amphipods) and fish (e.g., mountain whitefish [*Prosopium williamsoni*], lake whitefish [*Coregonus clupeaformis*], kokanee [*Oncorhynchus nerka*]), depending on prey availability and competitive pressures (Donald and Alger 1992).

Anadromous bull trout migrate to saltwater between 2 and 4 years of age, although individuals as young as age-1 and as old as age-7 have been captured as outmigrants (Goetz et al. 2004). Approximately 84 percent of bull trout outmigrants captured in northern Puget Sound were age-3 fish (Goetz et al. 2004).

Bull trout in the nearshore ecosystem rely upon estuarine wetlands and favor irregular shorelines with unconsolidated substrates over rocky (consolidated) habitat types (Goetz 2004). Juveniles may rear within estuarine wetlands and tidally influenced distributary channels (Goetz et al. 2004), while sub adult bull trout have been observed utilizing tidal sloughs in the Chehalis River and tidally influenced floodplain areas of Puget Sound (US Fish and Wildlife 2004). The distribution of bull trout in the nearshore ecosystem is thought to be dependent upon the abundance and distribution of prey items such as sand lance (*Ammodytes hexapterus*), juvenile salmonids (*Oncorhynchus* spp.), surf smelt (*Hypomesus pretiosus*), and pacific herring (*Clupea pallasii*). Bull trout are opportunistic feeders, and diet appears to vary seasonally with the availability of prey items (Goetz et al. 2004).

Anadromous bull trout originating in the Skagit River tend to grow larger than their fluvial counterparts because marine habitats are more productive and provide better foraging opportunities. Age-5 anadromous fish were, on average, nearly 80 millimeters longer than age-5 fluvial bull trout. The larger size of anadromous fish is thought to confer several reproductive advantages including the development of larger and more numerous eggs. Bull trout tend to use the nearshore ecosystem during the spring and late summer months, but do not forage exclusively in the marine environment. Individuals have been observed to migrate hundreds of kilometers through the nearshore ecosystem, to forage in different river basins (Goetz et al. 2004). These basin to basin migrations are difficult to document and are not currently well understood.

4-1.5 Population Trends

Although little is known about the historic abundance of bull trout, current population segments are geographically isolated from each other due to natural and anthropogenic barriers. In 1998 the Washington Department of Fish and Wildlife evaluated 80 bull trout / Dolly Varden stocks within the state of Washington and found that 17 percent were “healthy”, 3 percent were “depressed”, and 8 percent were “critical”, with the status of the remaining 72 percent “unknown” (Washington Fish and Wildlife 2000). Of the stocks whose status was known, 63 percent were rated as healthy.

4-1.6 Assessment of Threats Warranting ESA Protection

The following threats were listed as reasons for the decline of bull trout populations by US Fish and Wildlife in their 2004 Draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout (*Salvelinus confluentus*).

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Activities that lead to higher water temperatures, such as removal of riparian vegetation and some forest management practices, can effect bull trout survival. Dams and water diversions can impose migration barriers and degrade downstream habitats. Eutrophication caused by high nutrient levels in fertilizers from agriculture, fish hatchery, lumber mill runoff and urban/suburban areas may also negatively affect this species by decreasing the dissolved oxygen concentration in the water.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Sport fishing can lead to the overharvest of bull trout. The accidental bycatch of bull trout most likely occurs from sport anglers, commercial, and tribal fishers targeting other salmonid species. There are no known scientific or educational uses for bull trout.

DISEASE OR PREDATION

Although juvenile bull trout likely serve as forage fish for larger trout and salmon, insufficient information exists to determine whether disease or predation are current threats to bull trout survival. It is important to note that small, isolated populations can be highly sensitive to disease or an increase in predation from native or species.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Due to similarities in morphology, life history requirements, and habitat utilization for bull trout and Dolly Varden, the state of Washington has developed a single management plan for both species (Washington Fish and Wildlife 2000). The illegal harvest of bull trout does occur in portions of their habitat and may impact local populations. These fish

are especially vulnerable to poaching during their pre-spawning aggregations or while on their spawning grounds. The remoteness of these locations makes enforcement of existing regulations difficult.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Bull trout are known to hybridize with the non-native brook trout (*Salvelinus fontinalis*) where their populations overlap and may therefore be at risk through hybridization. In addition, brook trout seem to adapt better than bull trout in degraded or warmer stream habitats and as a result are believed to out-compete bull trout in these areas (US Fish and Wildlife 2004). Dams, culverts, tide gates and other water diversion structures also impact bull trout and contribute to fragmentation of migratory corridors, isolation of fish populations, and the elimination of historical habitats. These structures have been identified as barriers to fish migrations throughout the bull trout's range.

4-1.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Bull trout are likely to be affected by a variety of activities authorized by Washington DNR on state-owned riverine, estuarine, and nearshore marine areas. In addition to providing a refuge for salmon predators, overwater structures frequently reduce or prevent the growth vegetated habitat by preventing the transmission of light. Outfalls may cause localized reductions in water and sediment quality, resulting in increased turbidity, reduced foraging efficiency, diminished habitat quality, and potential bioaccumulation of pollutants. Construction of roads and bridges may result in increased sedimentation during construction, as well as increase temperature and pollutant loads from stormwater runoff during operation. Dredging, fill, shoreline armoring, and sand and gravel mining may either remove habitat or prevent the formation of habitat, or alter sediment loads, thereby decreasing habitat through increased scour or deposition. Aquaculture operations may result in disease transmission, decreased dissolved oxygen levels and genetic dilution. They may also impact salmon through the increases in nitrogenous waste and the introduction of chemicals such as anti-foulants, pesticides and antibiotics.

4-1.8 Species Coverage Recommendation and Justification

It is recommended that bull trout be addressed as a **Covered Species** for the following reasons: 1) Bull trout are currently listed as Threatened under the federal Endangered Species Act; 2) Washington DNR authorized activities have a "high" potential to affect bull trout; and 3) Although information gaps exist, bull trout and their habitat have been sufficiently studied to assess impacts and develop conservation measures.

4-1.9 References

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- Washington Department of Fish and Wildlife. 2000. Bull Trout and Dolly Varden Management Plan. Olympia, Washington.
- Washington Department of Fish and Wildlife. 2000. Washington State Salmonid Stock Inventory. Bull Trout / Dolly Varden. Olympia, Washington.
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4-2 Coastal Cutthroat Trout

4-2.1 Species Name

Oncorhynchus clarki clarki

Common Name: Coastal cutthroat trout

The coastal cutthroat is one of four major subspecies for *O. clarki* (Behnke 1992).

Initial coverage recommendation: Evaluation

4-2.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not listed

WASHINGTON FISH AND WILDLIFE STATUS

Not listed

NATURAL HERITAGE PROGRAM GLOBAL RANK

G4, T4

NATURAL HERITAGE PROGRAM STATE RANK

S?

4-2.3 Range

Coastal cutthroat trout are distributed along the western coast of North America from the Kenai Peninsula in Alaska to the Eel River in California with their inland distribution typically limited to less than 150 km from the coast (Behnke 1992). NOAA Fisheries (Johnson et al. 1999) recognized 6 Evolutionarily Significant units in the contiguous United States: 1) Puget Sound; 2) Olympic Peninsula; 3) Southwestern Washington; 4) Upper Willamette River; 5) Oregon Coast; and 6) Southern Oregon/California. The distribution of coastal cutthroat trout within the state of Washington includes large rivers and small tributaries of the Columbia River up to the Bonneville Dam and drainage basins on the west side of the Cascade Mountains, including the Olympic Peninsula

(Appendix F). The state of Washington currently recognizes 40 stock complexes - groups that typically occur in a limited geographic area and are believed to be closely related (Wydoski and Whitney 2003).

4-2.4 Habitat Use

ADULT

Coastal cutthroat trout exhibit resident, fluvial, adfluvial, and anadromous life history forms. Resident coastal cutthroat trout utilize small headwater streams for all of their life-stages and may reside within a few hundred meters of where they were born. Resident fish tend to be small as adults (15 to 30 centimeters in length), with anadromous individuals living to 10 years of age and attaining lengths of 43 to 48 centimeters (17 to 19 inches) (Pauley et al. 1988).

SPAWNING/INCUBATION/EMERGENCE

The timing of coastal cutthroat spawning migrations vary widely depending on life history form, age, stock characteristics, and geography (Behnke 1992), and may occur from July through January. This species spawns in small tributaries with total drainage areas of less than 13 square kilometers (Pauley et. al 1988) typically spawning upstream of areas used by steelhead trout and coho salmon for spawning. Although coastal cutthroat trout are iteroparous (repeat spawners), many anadromous fish do not spawn upon their first return to freshwater (Pauley et. al 1988). Anadromous, adfluvial, and resident stocks in Lake Washington appear to have segregated the time at which spawning occurs (December through May) and may be reproductively isolated (Wydoski and Whitney 2003). Substrates selected for spawning typically range in size between 0.1 and 30 centimeters.

Egg development is dependent on temperature, and 10° to 11° Celsius is considered optimal (Pauley et al 1988; Johnson et al 1999), with incubation lasting 6 to 7 weeks. The success rate for incubation to emergence has been shown to decrease with increasing percentage of fine sediments in the interstitial spaces of the gravel.

REARING/OUTMIGRATION

Coastal cutthroat trout typically rear in their natal streams for up to 2 years, occupying streams with gradients ranging between approximately 2 to 9.7 percent (Moore and Gregory 1998a; Connolly and Hall 1999). Resident fish may remain in these streams for their entire life while migratory fish move out to larger rivers, lakes and estuaries.

Young-of-the-year utilize low velocity habitats such as side channels and the lateral margins of streams. Moore and Gregory (1989a and 1989b) found that fry and juvenile fish in stream reaches with an abundance of velocity refuges attained larger sizes than fish in reaches with less cover. While fry and juvenile cutthroat trout are typically found in velocity refuges within shallow-faster habitat units, adult cutthroat trout prefer to reside in deeper pools with slower velocities. Young fish feed primarily on aquatic invertebrates but are opportunistic and will utilize other food sources such as terrestrial invertebrates, zooplankton and fish eggs (Pauley et al 1988). Resident cutthroat trout

may subsist entirely on insects while their migratory counterparts become increasingly piscivorous with increasing size.

Adfluvial coastal cutthroat trout may use both littoral and limnetic habitats and feed openly in the water column in the absence of predatory and competitive pressures (Wydoski and Whitney 2003). Fluvial and adfluvial coastal cutthroat trout typically migrate out of their natal streams between 1 and 4 years of age (Wydoski and Whitney 2003), with most migrating to saltwater during the spring at 2 to 4 years of age (Meehan and Bjornn 1991). In Washington, 97 to 100 percent of out-migrants were ages 2 and 3 (Wydoski and Whitney 2003). Because these fish spawn high in the tributaries they are likely to encounter virtually all of the riverine, lake, and wetland habitat types identified in this analysis.

Coastal cutthroat trout forage in estuarine wetlands, as well as nearshore coastal and inland waters, and typically occur in water less than 3 meters in depth (Pauley et al. 1988). Available information indicates that this species occurs at river deltas, distributary channels, and along shallow shorelines (Pauley et al. 1988, Johnson et al. 1999) thus demonstrating some preference for unconsolidated habitats. Although this review did not find evidence of the use of consolidated and neritic habitat use in the marine environment, evidence from freshwater lakes indicates that this behavior cannot be ruled out.

While evidence suggests that coastal cutthroat trout rarely occur in waters greater than 3 meters deep (Pauley et al. 1988), the species has been captured by fishing vessels up to 80 kilometers (55 miles) off the Oregon/Washington coast (Wydoski and Whitney 2003). Little is currently known about habitat utilization in the offshore ecosystem and although it is widely believed that the species does not overwinter at sea, the possibility cannot currently be ruled out.

4-2.5 Population Trends

Coastal cutthroat trout stocks in Washington, Oregon and California appear to be declining (Johnson et al 1999) whereas stocks in Alaska and British Columbia are apparently stable (Wydoski and Whitney 2003). As part of the 2000 coastal cutthroat trout salmonid stock inventory, the Washington Department of Fish and Wildlife determined that 2 percent of the stocks within the state were healthy, 18 percent were depressed, and the status of 80 percent of the stocks were unknown (Washington Fish and Wildlife 2000).

4-2.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Since cutthroat trout spawn in small headwater streams they are particularly susceptible to forest management practices that directly or indirectly alter water temperature, decrease dissolved oxygen, increase fine sediment loads, alter the amount of woody debris, or remove riparian vegetation. Dams and water diversions can impose migration barriers and degrade downstream habitats as well. Eutrophication caused by high nutrient levels in fertilizers from agriculture, fish farm waste, lumber mill runoff and urban/suburban areas may also negatively affect this species by decreasing the dissolved oxygen concentration in the water.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Coastal cutthroat trout are a popular gamefish in both freshwater and marine environments. While sport fishing can lead to the overharvest of cutthroat, angling restrictions have resulted in increased population size (Washington Fish and Wildlife 2000). The accidental bycatch of cutthroat trout most likely occurs from sport anglers, commercial, and tribal fishers targeting other salmonid species.

DISEASE OR PREDATION

Although juvenile cutthroat trout likely serve as forage fish for larger trout and salmon, insufficient information exists to determine that disease or predation is a current threat to cutthroat trout survival. However it is important to note that small, isolated populations can be highly sensitive to disease events or an increase in predation rates from native or introduced predators.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

The illegal harvest of cutthroat trout does occur in portions of their habitat and may impact local populations. These fish are especially vulnerable to poaching during their pre-spawning aggregations or while on their spawning grounds. The remoteness of these locations makes enforcement of existing regulations difficult.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Dams, culverts, tide gates, and other water diversion structures have been identified as barriers to fish migrations throughout the cutthroat trout's range and have led to the fragmentation of migratory corridors, isolation of fish populations, and the elimination of historical habitats. Cutthroat may also be at risk due to hybridization with rainbow trout (*Oncorhynchus mykiss*) in parts of its range where their populations overlap (Behnke 1992). Behnke (1992) hypothesizes that the two species are unable to resist

crossbreeding in streams with limited niche diversity and limited space for physical separation.

4-2.7 Assessment of Potential Effects for Washington DNR Authorized Activities

Cutthroat trout are likely to be affected by a variety of activities authorized by Washington DNR on state-owned aquatic rivers, estuaries, and nearshore marine areas. In addition to providing a refuge for salmon predators, overwater structures frequently reduce or prevent the growth of vegetated habitat by preventing the transmission of light. Outfalls may cause localized reductions in water and sediment quality, resulting in increased turbidity, reduced foraging efficiency, diminished habitat quality, and potential bioaccumulation of pollutants. Construction of roads and bridges may result in increased sedimentation during construction, as well as increase temperature and pollutant loads from stormwater runoff during operation. Dredging, fill, shoreline armoring, and sand and gravel mining may either remove or prevent the formation of habitat, or alter sediment loads, thereby decreasing habitat through increased scour or deposition. Aquaculture operations may result in disease transmission, decreased dissolved oxygen levels and genetic dilution. They may also impact salmon through the increases in nitrogenous waste and the introduction of chemicals such as anti-foulants, pesticides and antibiotics.

4-2.8 Species Coverage Recommendation and Justification

It is recommended that cutthroat trout be addressed as a **Covered Species** for the following reasons: 1) Cutthroat trout are currently listed as a Species of Concern under ESA and the present destruction, modification, or curtailment of its habitat or range especially in the nearshore is considered significant; 2) Cutthroat trout have a “high” potential to be affected by Washington DNR authorized activities due to their dependence on submerged habitat; and 3) Although information gaps exist, cutthroat trout have been sufficiently studied to assess impacts and develop conservation measures.

4-2.9 References

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4-3 Chinook Salmon

4-3.1 Species Name

Oncorhynchus tshawytscha

Common Name(s): Chinook salmon, king salmon, tyee salmon, spring salmon

Initial coverage recommendation: Covered

4-3.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS (NOAA FISHERIES 2005)

Evolutionarily Significant Unit	Status
Upper Columbia River Spring-Run	Threatened (1999)
Lower Columbia River	Threatened (1999)
Snake River Spring-Run	Threatened (1992)
Snake River Fall-Run	Endangered (1992)
Puget Sound	Threatened (1999)
Middle Columbia River Spring-Run	Not Listed
Upper Columbia River Fall-Run	Not Listed
Washington Coast	Not Listed

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Population/Stock	State Status
Lower Columbia River	Candidate
Upper Columbia River Spring-Run	Candidate
Puget Sound	Candidate
Snake River Fall-Run	Candidate
Snake River Spring-Run	Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Location	Global Rank
Lower Columbia River	G5, T2Q
Upper Columbia River Spring-Run	G5, T1Q
Puget Sound	G5, T2Q
Washington Coast	G5, T2Q
Snake River Fall-Run	G5, T1Q
Snake River Spring-Run	G5, T1Q

NATURAL HERITAGE PROGRAM STATE RANK

Population	State Rank
Lower Columbia River	S3S4
Upper Columbia River Spring-Run	S3S4
Puget Sound	S3S4
Washington Coast	S3S4
Snake River Fall-Run	S3S4
Snake River Spring-Run	S3S4

4-3.3 Range

The historical range of Chinook salmon included most of the North Pacific Ocean from California to Alaska, through the Aleutian Islands and into Siberia. This species probably inhabited most rivers and larger streams in Washington, Oregon and California. Some populations now considered extinct, are believed to have migrated hundreds of miles inland to spawn in tributaries of the Upper Columbia River and the Snake River (Healey 1991; Meehan 1991; Myers et al. 1998; Wydoski and Whitney 2003).

Currently, Chinook salmon are found in the rivers and streams of Puget Sound, including Hood Canal and the Strait of Juan de Fuca, the Pacific coast, and the Columbia River and its tributaries (Wydoski and Whitney 2003). Degradation and loss of habitat in the headwaters of many Washington rivers now limits their spawning range (Wydoski and Whitney 2003). Some landlocked populations occur in Lake Washington, Lake Cushman and Lake Roosevelt (Wydoski and Whitney 2003). Figures representing the freshwater distribution of summer, spring and fall Chinook salmon in Washington may be found in Appendix F.

4-3.4 Habitat Use

The life history of Chinook salmon is typical of Pacific salmon in general, whereby spawning occurs in freshwater habitats, and juveniles rear in freshwater for a period of time before migrating to salt water, where they mature and spend several years before returning to their natal streams to spawn. However, the variety of life-history types among Chinook salmon makes their habitat requirements especially complex.

Chinook are generally divided into three categories based on when they return to freshwater—spring run (March to May), summer run (June and July) and fall run (August and September) (Wydoski and Whitney 2003). All Chinook spawn in the fall with the spring runs spawning first in headwater streams, followed by summer Chinook in tributary mouths and fall types in mainstem tributaries (Wydoski and Whitney 2003). This species also exhibits one of two life-history types, or races: the stream-type and the ocean-type (Myers et al. 1998). Stream-type Chinook tend to spend one or more years in freshwater environments as juveniles prior to migrating to saltwater as smolts. Ocean-type Chinook spend between 3 months and 1 year in freshwater before smolting and migrating to estuarine or nearshore areas in saltwater. Ocean-type Chinook are more

dependent on estuarine habitats to complete their life history than any other species of salmon (Healey 1991).

ADULT

Chinook are the largest of the Pacific salmon with an average length of approximately 1 meter and weights ranging from 1 to 56 kilograms (Wydoski and Whitney 2003), and tend to spawn in large river systems (Meehan 1991). The species spends between 2 and 6 years at sea prior to returning to fresh water to spawn, but this time varies between stocks and also depends somewhat on ocean conditions (Meehan 1991; Wydoski and Whitney 2003). Similarly to other salmonids, Chinook spawn in cold, highly oxygenated water (Healey 1991). Spring Chinook are especially dependent on high water quality and good access to spawning areas as they move upstream during periods of lower flow and hold in rivers for extended periods of time before spawning. Adult spring Chinook salmon tend to prefer deep, cool “holding pools” with woody debris, over-hanging vegetation and undercut banks to protect them from predators (Healey 1991). Chinook generally feed on invertebrates, but become more piscivorous with age (Healey 1991), feeding on sandlance, sticklebacks, crab larvae and small herring while at sea (Healey 1991).

SPAWNING/INCUBATION/EMERGENCE

In Washington, Chinook spawn using sites with escape cover, such as logs, undercut banks and deep pools (Meehan 1991) and dominated by large gravel or cobble that is between 2.5 and 15 centimeters (1 and 6 inches) in diameter (Healey 1991). Although adults usually die soon after spawning, females may guard a redd from 4 to 25 days before dying (Healey 1991). Chinook, like other salmonids, will often use areas where other salmon have spawned earlier in the year (Meehan 1991).

While the length of time it takes for eggs to hatch is heavily dependent on water temperature, Chinook eggs generally hatch between 90 and 150 days after deposition. Optimal temperature for incubation is between 7 and 10° Celsius and although eggs hatch sooner in warmer water, the young fish are smaller and generally have lower survival rates (Healey 1991). After hatching, the developing Chinook will typically remain in the gravel for several months prior to emergence (Healey 1991). Newly emerged fry move to shallow, protected areas of the stream, usually seeking out pools formed by large woody debris, where they establish and defend feeding areas (Meehan 1991).

REARING/OUT-MIGRATION

Juvenile Chinook may spend from 3 months to 2 years in freshwater after emergence and before migrating to estuarine areas as smolts. Younger juveniles generally seek out covered areas with lower flow near the edges of stream and river channels, moving to higher velocity, midstream areas as they mature (Healey 1991). Young-of-the-year feed primarily on larval and adult aquatic insects, such as mayflies, caddisflies and chironomids, as well as terrestrial insects (ants, spiders, beetles), earthworms, and crustaceans (Healey 1991).

Ocean type juveniles are typically the result of fall and summer run spawning events and begin slowly moving downstream shortly after they emerge from the redds (Wydoski and Whitney 2003). However, stream-type juveniles over-winter in freshwater for at least 1 year, beginning their downstream migration in the spring of the following year (Wydoski

and Whitney 2003). Stream-type juveniles in systems with higher percentages of large woody debris show higher over-winter survival (Murphy et al. 1986). Juvenile Chinook have also shown a preference for seasonally inundated floodplain areas in larger river systems (Sommer et al. 2001).

At the time of saltwater entry, stream-type (yearling) smolts are much larger than their ocean-type (sub-yearling) counterparts, and do not rely heavily on estuaries for rearing, moving offshore relatively quickly. In contrast ocean-type Chinook typically migrate to estuaries within 3 months of emergence, averaging about 50 to 70 millimeters and make extensive use of estuarine and nearshore habitat for rearing (Healey 1991).

4-3.5 Population Trends

Catch records for Washington's Chinook have fluctuated cyclically within the last 30 years, but reached record-low levels during the early 1990s. In general, Chinook populations throughout the Pacific Northwest are considered depressed from historical levels. The National Oceanic and Atmospheric Administration (NOAA) Fisheries recognizes 17 Evolutionarily Significant Units (ESUs) for Chinook, several of which are located within Washington State (Myers et al. 1998).

Washington Coast

This ESU includes the coastal basins north of the mouth of the Columbia River to, but not including, the Elwha River. Long-term trends for most populations in this ESU have been upward; however, several smaller populations are experiencing sharply downward trends. Fall-run populations are predominant and tend to be at a lower risk than spring or summer runs. Hatchery production is significant in the southern portion of this ESU, whereas the majority of the populations in the northern portion of the ESU have minimal hatchery influence (Myers et al. 1998).

Puget Sound

The Puget Sound ESU contains coastal basins of the eastern part of the Strait of Juan de Fuca, Hood Canal and Puget Sound. This region includes the Elwha River and extends to the Nooksack River basin and the United States-Canadian border. Total abundance in this ESU is relatively high; however, much of this production is hatchery-derived. Both long- and short-term trends in abundance are predominantly downward, and several populations are exhibiting severe short-term declines, with spring-run Chinook throughout this ESU depressed. NOAA Fisheries has expressed concern that the high level of hatchery production may be masking more severe underlying trends in abundance. In many areas, spawning and rearing habitats are severely degraded and migratory access has been restricted or eliminated (Myers et al. 1998).

LOWER COLUMBIA RIVER

The Lower Columbia River ESU contains tributaries to the Columbia River from the mouth of the Columbia River to, but not including, the Klickitat River. While abundance in this ESU is relatively high, the majority of the fish appear to be hatchery-produced. The fall Chinook salmon run in the Lewis River appears to be the only healthy, naturally

occurring population in this ESU and both long- and short-term trends in abundance for the ESU are negative, some severely so. The numbers of naturally spawning spring runs are so low that NOAA Fisheries was unable to identify any healthy, native, spring-run populations. The pervasive influence of hatchery fish in almost every river in this ESU and the degradation of freshwater habitat suggest that many naturally spawning populations are not able to replace themselves (Myers et al. 1998).

MIDDLE COLUMBIA RIVER

The Middle Columbia River ESU includes tributaries to the Columbia River from the Klickitat River Basin upstream to include the Yakima River Basin, excluding the Snake River Basin. Chinook abundance in the ESU has declined considerably from historical levels, but appears to be relatively stable during recent years. Natural production accounts for most of the escapement in the Yakima and Deschutes River basins. Habitat degradation, especially due to agricultural practices, affects most of the rivers in this ESU (Myers et al. 1998).

UPPER COLUMBIA RIVER

The Upper Columbia River Fall- and Summer-Run Chinook ESU contains tributaries to the Columbia River upstream of the confluence of the Snake and Columbia Rivers to the Chief Joseph Dam. Chinook abundance in this ESU is quite high, although naturally spawning Chinook salmon in the Hanford Reach are responsible for the vast majority of the production. NOAA Fisheries was concerned about the recent decline in summer-run populations in this ESU and the apparent increase in the contribution of hatchery return to total escapement. It was unclear whether, under current conditions, the naturally spawning summer-run Chinook salmon populations are self-sustaining (Myers et al. 1998).

The Upper Columbia River Spring-Run Chinook ESU includes tributaries to the Columbia River upstream from the Yakima River to the Chief Joseph Dam. Chinook abundance in this ESU has been generally low. At least six populations of spring-run Chinook salmon in the ESU have been extirpated, and almost all remaining naturally spawning populations have fewer than 100 spawners. Hydroelectric and irrigation dams have blocked access to much historical habitat and directly impeded adult and smolt migrations. NOAA Fisheries concluded that this ESU is currently at risk of extinction (Myers et al. 1998).

SNAKE RIVER

The Snake River Fall-Run ESU contains tributaries to the Columbia River from the Dalles Dam to the confluence of the Snake and Columbia Rivers, including the Snake River Basin. Although historically, the Snake River component of this ESU was the predominant source of production, the current 5-year average for Snake River fall-run Chinook salmon is about 500 adults with dams blocking access to most of the historic spawning habitat and migration corridors. Snake River fall-run Chinook salmon are currently listed as a Threatened species, with NOAA Fisheries concluding that the newly defined Deschutes River population is likely to become in danger of extinction in the foreseeable future (Myers et al. 1998).

The Snake River Spring- and Summer-Run ESU includes tributaries to the Snake River upstream of the Snake and Columbia Rivers' confluence. Recent abundance of the naturally spawning population for this ESU has averaged about 2,500 fish, compared with historical levels of approximately 1.5 million. Both long- and short-term trends are negative for all populations. A number of populations have been extirpated in this ESU, primarily due to dam construction (Myers et al. 1998).

4-3.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Habitat degradation and loss, in freshwater, estuarine and marine systems is thought to be a significant contributing factor to Chinook population declines in Washington and throughout the Pacific Northwest region (Myers et al. 1998). Habitat degradation and loss has been linked to timber harvest activities, agriculture and grazing, and urbanization (Stouder et al.1997). Hydroelectric dams and irrigation withdrawals have also been linked to the decline of Chinook populations, especially those in the Lower Columbia River (Stouder et al. 1997). Increases in siltation can lead to increased embryo mortality as a result of smothering and may also lead to decreased juvenile survival by shifting food webs to less favorable prey (Meehan 1991).

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Fishing pressure from commercial and recreational sources has been identified as a contributing factor in the decline of Chinook populations (Stouder et al.1997).

DISEASE OR PREDATION

Neither disease nor predation has been identified as significant threats to the species as a whole (Stouder et al.1997).

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Regulatory mechanisms are in place, including management plans for specific river drainages. However, it is not clear that these measures have been effective in protecting wild Chinook populations. In addition, the implications of hatchery fish on native populations are not fully known. Current harvest regulations also may not be adequate to protect wild stocks. Finally, it is not clear whether current regulations governing land-use activities (timber harvest, agriculture and urban/suburban development) will be adequate to prevent further habitat degradation or loss.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Chinook salmon have been identified as a Threatened or Endangered species in Washington primarily because of degradation or loss of habitat, overharvest and pressure from hatchery stocks (NOAA Fisheries 2005). Fish-passage barriers have long been a

problem for Chinook, which often utilize upper tributaries to spawn. Additionally, unfavorable climatic conditions during the last several years may have negatively impacted marine survivability for Chinook.

4-3.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Chinook are likely to be affected by a variety of activities authorized by Washington DNR on state-owned rivers, estuaries and nearshore marine areas. Overwater structures frequently reduce or prevent the growth vegetated habitat by preventing the transmission of light and provide a refuge for salmon predators. Outfalls may cause localized reductions in water and sediment quality, resulting in increased turbidity, reduced foraging efficiency, diminished habitat quality and increased potential for the bioaccumulation of pollutants. The construction of roads and bridges may result in increased sedimentation during construction, and may increase temperature and pollutant loads from stormwater runoff during operation. Pollutants that are harmful to salmonids and present in stormwater runoff and outfalls include but are not limited to hormones, PCBs, heavy metals, salts, and petroleum products. Aquaculture operations may result in disease transmission, decreased dissolved oxygen levels and genetic dilution. They may also impact salmon through the increases in nitrogenous waste and the introduction of chemicals such as antifoulants, pesticides and antibiotics.

4-3.8 Species Coverage Recommendation and Justification

It is recommended that Chinook be addressed as a **Covered Species** for the following reasons: 1) Five Chinook ESUs in the state of Washington are federally listed as Threatened, Endangered or Candidate Species; 2) Washington DNR authorized activities have a “high” potential to affect Chinook; and 3) Sufficient information exists to assess impacts and to develop conservation measures.

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4-4 Chum Salmon

4-4.1 Species Name

Oncorhynchus keta

Common Name(s): Chum salmon, dog salmon and calico salmon

Initial coverage recommendation: Covered

4-4.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS (NOAA FISHERIES)

Evolutionarily Significant Unit	Status
Hood Canal Summer-run	Threatened (1999)
Columbia River	Threatened(1999)
Puget Sound / Strait of Georgia	Not Warranted
Pacific Coast	Not Warranted

WASHINGTON FISH AND WILDLIFE STATUS

Location	State Status
Hood Canal Summer-run	State Candidate
Lower Columbia	State Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Name	Global Rank
Hood Canal Summer-run	G5T2Q
Lower Columbia River-run	G5T2Q
Northwest Anadromous	G5T3Q

NATURAL HERITAGE PROGRAM STATE RANK

Name	State Rank
Hood Canal Summer-run	S?
Lower Columbia River-run	S?
Northwest Anadromous	S?

4-4.3 Range

Chum salmon have the most extensive distribution of all Pacific salmon, with their western reach encompassing Korea, Japan and Russia, including the Arctic coast. The

eastern portion of their range includes California, Oregon, Washington and Alaska including the Arctic coast (Salo 1991; Wydoski and Whitney 2003). Previous studies have found that North American chum salmon migrate throughout the North Pacific Ocean and Bering Sea but are not commonly found west of the mid-Pacific Ocean (Neave et al. 1976; Salo 1991). Although little is known regarding their ocean distribution, maturing individuals that return to Washington streams have primarily been found in the Gulf of Alaska. Chum salmon are rarely found in northern California and southern Oregon (Kostow 1995; Johnson et al. 1997).

In Washington, chum salmon are usually found in the rivers and streams of the Washington coast, Hood Canal, Strait of Juan de Fuca and Puget Sound. In the Columbia River Basin, their range does not extend above the Dalles Dam and they are rarely found above Bonneville Dam (Wydoski and Whitney 2003). A figure representing the freshwater distribution of chum salmon in Washington may be found in Appendix F. NOAA Fisheries recognizes 72 separate stocks of chum salmon within Washington State. The stocks are divided into 4 evolutionarily significant units (ESUs) including Puget Sound / Strait of Georgia, Hood Canal Summer-run, Pacific Coast and Columbia River (Johnson et al. 1997).

4-4.4 Habitat Use

ADULT

In Washington, chum salmon rear in the ocean for the majority of their adult lives until they reach maturity (Salo 1991; Wydoski and Whitney 2003). The species maintain a variety of life history strategies that exhibit regional differences in age and size at maturity. Chum salmon mature between the ages of 2 and 6, with adults having an average lifespan of 4 years (Wydoski and Whitney 2003; Froese and Pauly 2004). In size and weight, chum salmon are second only to Chinook salmon, reaching up to 108 centimeters in length and 20.8 kilograms in weight. While little information exists regarding the high seas habitat usage of regionally specific stocks, chum salmon are distributed across the North Pacific Ocean and Bering Sea during offshore marine rearing. Upon reaching maturity, adults begin their homeward migration between May and June, entering coastal streams from June to November (Neave et al. 1976).

SPAWNING/INCUBATION/EMERGENCE

Chum salmon are anadromous (maturing in saltwater and spawning in freshwater) and semelparous (i.e. they perish after spawning). Summer-run chum salmon enter Washington streams from June to August, spawning between mid-September and mid-October while fall run chum return from September to November, spawning between November and December (Johnson et al. 1997).

Chum salmon usually spawn in low elevation reaches because they are unable to negotiate riverine blockages or falls due to reduced swimming ability compared to other salmonids. However, in rivers that offer low gradients and relatively few obstacles such as the Yukon River in Alaska and the Skagit River in Washington, they can migrate more than 2,500 kilometers and 170 kilometers upstream respectively (Johnson et al. 1997).

Chum salmon typically spawn in channel types that include low gradient valleys, riffle pools and plane beds.

Spawning behavior for chum is similar to other salmon. Females select, prepare and guard their redd while engaging in constant territorial competition for the best locations, while males compete for breeding opportunities (Quinn 2005). A variety of features determine optimal redd sites, including water depth and velocity, gravel type and the presence of riparian vegetation for cover. It has been suggested that chum salmon have developed specific spawning habitat requirements because they often co-occur with pink salmon. Females typically avoid the slowest water, due to its inability to flush siltation and provide oxygen throughout the redd (Quinn 2005). Although water velocity criteria vary globally in Washington, Johnson (1971) found that 80 percent of spawning sites had velocities between 21.3 centimeters and 83.8 centimeters per second. The average water depth for chum salmon redds is approximately 0.5 meters (Quinn 2005), with the redds located in substrates ranging from medium gravel to bedrock strewn with boulders (Scott and Crossman 1973). Substrate that lacks excessive sedimentation is particularly important because it provides adequate flow of cold oxygenated water. While bed elements need to be large enough to protect the eggs from scouring events, egg burial ability dictates the maximum size of the gravel particles. In northern climates, where water levels can decrease in spawning areas with freezing temperatures, the presence of upwelling groundwater has been suggested as one of the most important habitat requirements for redd site selection (Reub 1990).

In North America, chum salmon produce between 2,000 and 3,600 eggs per female (Johnson et al. 1997), with alevin / fry survival rates positively correlated with egg size (Quinn 2005). Egg size is extremely important because most of the lifetime mortality occurs during incubation in the redd (Quinn 2005). Since egg development is dependent on temperature, high water temperatures can decrease the amount of hatching time by 1.5 to 4.5 months. In Washington, the time required to hatch varies from approximately 86 to 182 days, depending on location (Salo 1991).

REARING/OUTMIGRATION

Chum spend little time rearing in freshwater, with fry beginning their downstream migration shortly after hatching to rear in estuarine environments. In Washington, the fry migrate downstream from late January through June with migration peaking between April and June. Cues that dictate the timing of downstream migration include spawning date, stream temperature during incubation, fry length and condition, brood class strength, food availability, stream hydromorphology, distance to the estuary, and physiological changes in fry and day length (Salo 1991). In addition to chum fry being smaller than other salmon species, they usually migrate shorter distances and school less closely. Chum fry lack an obvious hiding response to disturbances, and as a consequence congregate toward the shade of waterweeds and riparian vegetation for refuge from predators (Salo 1991). Although there is little information concerning feeding behavior during downstream migration, chum fry have been observed to feed intensely upon chironomid and mayfly larvae, as well as other aquatic insects (Salo 1991).

Since marine survival greatly depends on size and chum fry arrive in estuaries earlier than most salmon, juvenile chum reside in estuaries longer than most other anadromous species (Healey 1982; Wydoski and Whitney 2003; Quinn 2005). Estuarine wetlands are

critical to chum salmon survival because they provide high prey abundance, an area of gradual transition from fresh to salt water, and an area with turbid water, shading, and vegetation to serve as refuge from predators and high temperatures (Quinn 2005).

Juveniles enter nearshore estuarine wetlands between February and May, with a peak in late-March to early-May (Simenstad et al. 1982), rearing in productive and shallow eelgrass beds until they reach 45 to 60 millimeters in length and move offshore. Juvenile habitat usage may be in part due to possible overlap with returning adult chum salmon (Hood Canal summer-run) which may feed upon juveniles (Johnson et al. 1997). Returning chum salmon adults are joined by juvenile coho (*Oncorhynchus kisutch*), cutthroat trout (*Oncorhynchus clarki*), and aquatic birds as major predators of chum juveniles in estuarine wetlands. In addition to predation, causes of mortality in estuaries include cold temperatures, extreme changes in water flow, habitat degradation, disease, as well as interspecific and exotic species competition (Johnson et al. 1997).

Generally, juveniles feed upon epibenthic crustaceans, with larger juveniles found farther offshore preying on terrestrial insects, copepods, amphipods and other zooplankton (Simenstad et al. 1982). It has been suggested that departure from estuarine wetlands into marine environments is connected to prey abundance and offshore migration may occur when nearshore prey availability becomes low. It may also occur when juveniles are large enough to feed on larger offshore zooplankton (Simenstad 1982; Salo 1991).

While little is known regarding residence time in estuaries, juveniles begin their seaward migrations in April, with larger fish leaving before smaller, lighter fish. The young fish migrate northward through Puget Sound to the Strait of Georgia and have been observed along the coast of Washington and the west coast of Vancouver Island by mid-May. Studies by Hartt and Dell in 1986 found that in their first year in the ocean, chum salmon tended to stay within 36 kilometers of the shore.

4-4.5 Population Trends

Information regarding population trends is largely lacking for chum salmon in Washington and elsewhere. Of the 72 recognized chum stocks in the state, Washington Fish and Wildlife considers only Chambers Creek summer-run to be extinct (Washington Fish and Wildlife et al. 1993). It is important to note that the report does not recognize historic extinctions. Half of the 18 stocks with an unknown status are from the West Coast of the Olympic Peninsula and the Strait of Juan de Fuca. Only two stocks are listed as critical, with three considered depressed, and the remaining 48 listed as healthy (Johnson et al. 1997).

PUGET SOUND / STRAIT OF GEORGIA ESU

For the past 30 years, commercial harvest has been increasing, with the bulk of the catch recorded from the Puget Sound / Strait of Georgia ESU. While not all of the 38 stocks in this ESU had sufficient data for analysis, of those that did 10 had negative population trends and 23 positive trends. Estimates from 1997 indicated that there are over 1.5 million adults in this population and that the overall was increasing (Johnson et al. 1997).

HOOD CANAL SUMMER-RUN ESU

Although the population trend for the Hood Canal summer-run chum salmon ESU has been decreasing for the past 30 years, escapement in some streams showed large increases in 1995 to 1996. Commercial fishing by tribal and non-tribal fishermen has historically targeted chum salmon in Hood Canal, which may have contributed to declining populations. Although chum are commonly caught as non-targeted bycatch, exploitation rates for summer run chum have been drastically reduced since 1991 from closures of the coho salmon and Chinook salmon fisheries (Washington Fish and Wildlife 1996).

COLUMBIA RIVER ESU

Although historical estimates place the Columbia River run in the hundreds of thousands, for the past 50 years, yearly returns have averaged in the thousands (NOAA Fisheries 2003). Although 2002 saw a dramatic increase in the abundance of returning adults in this ESU, in 2003 NOAA Fisheries concluded that Columbia River chum salmon are either likely to become Endangered or in danger of extinction (NOAA Fisheries 2003).

PACIFIC COAST ESU

Due to the broad geographic area of this ESU abundance data is generally lacking and it is difficult to estimate population trends. However, population estimates indicate that the stock is holding at approximately 150,000 adults in the Pacific Coast ESU (Johnson et al. 1997).

4-4.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Freshwater, estuarine and marine habitat loss or degradation is thought to be the primary reason for declining chum salmon populations. Similarly to ocean-type Chinook, chum's dependence on estuaries for fry and juvenile rearing leaves them more susceptible to the loss of estuarine habitat than other Pacific salmonids. On average, 18 to 64 percent of estuarine habitat in Washington has been lost (Simenstad et al. 1982; Hutchinson 1989) to diking, channelization, dredging and filling, road building and/or industrialization (Johnson et al. 1997). Excessive sediment loading from gravel mining and dredging can result in increased embryo mortality by decreasing the flow of oxygenated water to the eggs while in gravel. The removal of woody debris from rivers, streams and estuaries to improve navigability, decrease channel meander, and aesthetically improve "views" has resulted in a significant loss of refuge from predators and may increase scour from high flow events caused by water releases from dams and flooding. Bank armoring impacts juveniles by removing refuge from predators found with undercut banks, log snags, and streamside vegetation. The loss of streamside vegetation also leads to increased temperatures that can be detrimental to chum as well as decreases in terrestrial insect prey sources. In addition, bank armoring also alters substrate, which can lead to declines in

eelgrass and kelp beds, which provide important habitat and prey sources for chum salmon. Point source and non-point source pollution can have deleterious effects on food web assemblages in freshwater, estuarine and marine habitat. Since chum salmon utilize the lower reaches of rivers, hydropower development may not be a significant concern for the species, but eggs and young may still be at risk from water level fluctuation related to dam and water diversions.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Chum salmon are targeted for recreational, sport and commercial fisheries, and have historically been subject to overfishing. This is particularly true in the lower Columbia where harvest levels may have reached up to 80 percent of the yearly runs. Although the existing fishery is highly regulated, recreational, sport and commercial fisheries continue to present a threat to the continued existence of chum salmon. Because oceanic harvest cannot differentiate between summer runs and fall runs, it may continue to put summer runs at risk. Additionally, chum salmon are often caught as bycatch.

DISEASE OR PREDATION

Genetic dilution and increased risk of disease transmission from hatcheries have been recently cited as concerns for chum salmon populations (Johnson et al. 1997). Similar concerns have been raised for exotic introductions of Atlantic salmon through the practice of net-pen fish farming. Atlantic salmon aquaculture may also cause extremely high sea lice (*Lepeophtheirus salmonis*) infestation rates in chum salmon (Morton et al. 2004). Because net pen farms may offer suitable overwintering habitat for sea lice, and chum salmon are small during their nearshore life stage, sea lice infection may cause excessively high mortality for chum salmon (Morton et al. 2004). Disease from sea lice infection includes skin erosion and hemorrhaging that can result in lethal bacterial infections, fungal infections and osmoregulatory failure (Wootten et al. 1982).

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Chum salmon may be at risk due to the inadequacy of existing regulatory mechanisms governing land-use activities (timber harvest, agriculture, and urban/suburban development) and continued habitat loss and/or degradation. Furthermore, water quality regulations may also be inadequate to protect chum from the negative effects of pollution. Although regulations are in place regarding specific geographical harvest and hatchery rebuilding plans, recreational, sport, and commercial fisheries still may pose a threat to the existence of chum salmon. Current harvest regulations may not be adequate to protect these fish. It is also unclear whether current regulations surrounding hatchery based fishery enhancement and rebuilding efforts will protect the genetic integrity of wild chum salmon runs.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

In addition to hybridization and increased risk of disease, displacement by and competition for prey resources with hatchery-reared and introduced fish species may also impact chum. In addition, shifts in ocean climate, such as warming and cooling phases caused by the Pacific Decadal Oscillation and the El Nino Southern Oscillation can be detrimental to chum salmon populations. For instance, it has been suggested that early

ocean period mortality rates for chum salmon are positively correlated with high sea surface temperatures caused by warming events in coastal Washington (Mueter et al. 2005). Drought periods that create low water flows may dewater eggs or strand juveniles. Summer run chum salmon may be particularly at risk from cyclical drought due to their entrance in streams during times of exceptionally low flows, resulting in greatly reduced access to suitable spawning habitat.

4-4.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Chum are likely to be affected by a variety of activities authorized by Washington DNR on state-owned rivers, estuaries and nearshore marine areas. Overwater structures frequently reduce or prevent the growth of vegetated habitat by preventing the transmission of light and provide a refuge for salmon predators. Dredging, fill, shoreline armoring, and sand and gravel mining may either remove habitat or prevent the formation of habitat, or alter sediment loads, thereby decreasing habitat through increased scour or deposition. Outfalls may cause localized reductions in water and sediment quality, resulting in increased turbidity, reduced foraging efficiency, diminished habitat quality, and increased potential for the bioaccumulation of pollutants. The construction of roads and bridges may result in increased sedimentation during construction, and may increase temperature and pollutant loads from stormwater runoff during operation. Pollutants that are harmful to salmonids and present in stormwater runoff and outfalls include but are not limited to hormones, PCBs, heavy metals, salts, and petroleum products. Aquaculture operations may result in disease transmission, decreased dissolved oxygen levels and genetic dilution. They may also impact salmon through the increases in nitrogenous waste and the introduction of chemicals such as antifoulants, pesticides, and antibiotics.

4-4.8 Species Coverage Recommendation and Justification

It is recommended that chum salmon be addressed as a **Covered Species** because: 1) The Hood Canal summer run chum salmon ESU is currently federally listed as Threatened and it is unlikely that either its population status will improve or threats decrease to a level that would warrant de-listing in the foreseeable future. In addition, the Hood Canal summer run and Lower Columbia ESUs are listed as Candidate Species within Washington State; 2) Washington DNR authorized activities have a “high” potential to affect chum salmon; and 3) Sufficient information exists to assess impacts and to develop conservation measures.

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4-5 Coho Salmon

4-5.1 Species Name

Oncorhynchus kisutch

Common Name(s): Coho salmon, silver salmon, blueback

Initial coverage recommendation: Covered

4-5.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

National Oceanic and Atmospheric Administration (NOAA) Fisheries recognizes six ESUs for Coho. Three of these ESUs, Central California, Southern Oregon/Northern California Coasts and Oregon Coasts, were listed as Threatened under the Endangered Species Act (ESA) in October 1996, May 1997 and August 1998, respectively. The three ESUs located in Washington are not currently listed as Endangered or Threatened under the ESA.

FEDERAL STATUS (NOAA FISHERIES)

Evolutionarily Significant Unit (ESU)	Status
Lower Columbia River & SW Washington	Candidate
Puget Sound & Strait of Georgia	Candidate
Olympic Peninsula	Not Listed

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Population/Stock	State Status
Lower Columbia River & SW Washington	Not listed
Puget Sound & Strait of Georgia	Not listed

NATURAL HERITAGE PROGRAM GLOBAL RANK

Population	Global Rank
Lower Columbia River & SW Washington	G4, T2Q
Puget Sound & Strait of Georgia	G4, T3Q
Olympic Peninsula	G4, T3Q

NATURAL HERITAGE PROGRAM STATE RANK

Location	State Rank
Lower Columbia River & SW Washington	S?
Puget Sound & Strait of Georgia	S?
Olympic Peninsula	S?

4-5.3 Range

Coho salmon were historically distributed throughout the North Pacific Ocean from central California to Alaska, through the Aleutian Islands, and from Russia south to Japan. This species probably inhabited most of the coastal streams in Washington, Oregon and Central and Northern California. Some populations, now considered extinct, are believed to have migrated hundreds of miles inland to spawn in tributaries of the Upper Columbia River in Washington and the Snake River in Idaho (Groot and Margolis 1991; Nehlsen et al. 1991; Weitkamp et al. 1995; Wydoski and Whitney 2003). Coho salmon have also been introduced worldwide, becoming naturalized in many areas such as the Great Lakes.

There are believed to be 90 distinct stocks in Washington (Wydoski and Whitney 2003) with populations occurring throughout Puget Sound, Hood Canal, the Strait of Juan de Fuca, the Olympic Peninsula and the Columbia River Basin. A figure representing the freshwater distribution of coho salmon in Washington may be found in Appendix F.

4-5.4 Habitat Use

While the life history of coho salmon is typical of Pacific salmon, this species is found in a broader diversity of habitats than any of the other native anadromous salmonids, including headwater streams, small coastal creeks, and tributaries of major rivers (Meehan 1991).

ADULT

Most Coho spend between 1 and 2 years in the ocean before returning to spawn, although some males mature after only 5 to 7 months (Wydoski and Whitney 2003). At maturity coho weigh between 3 and 6 kilograms, with lengths ranging between 0.5 and 0.75 meters (Wydoski and Whitney 2003). Adult coho feed on invertebrates but become more piscivorous as they grow larger (Groot and Margolis 1991) commonly eating sand lance (*Ammodytes hexapterus*), sticklebacks (Gasterosteidae), crab larvae and small herring (*Clupea pallasii*) (Groot and Margolis 1991).

SPAWNING/INCUBATION/EMERGENCE

Although the timing is often unique for each run, in Washington coho generally return to freshwater environments beginning in August. Spawning occurs from September through January with the adults entering freshwater earliest moving the farthest upstream (Groot and Margolis 1991; Meehan 1991, Wydoski and Whitney 2003). Spawning behavior and requirements are similar to other salmonids, with females laying eggs in gravel areas free of heavy sedimentation with adequate flow and cool, clear water. Although adults usually die soon after spawning, escape cover, such as logs, undercut banks and deep pools for spawning adults are also important (Meehan 1991).

The length of time it takes for eggs to hatch and egg survival are heavily dependent on water temperature. In hatcheries, coho eggs usually hatch after about 30 to 40 days at a temperature of 10° Celsius. Eggs hatch sooner in warmer water, but the young fish are smaller and generally have lower survival rates. If the temperature goes too high, eggs will not hatch at all (Groot and Margolis 1991).

After hatching, the developing coho will typically remain in the gravel for around 3 months prior to emergence (Groot and Margolis 1991) obtaining nutrients from a yolk sack attached to their body. Upon emergence, fry move to shallow, protected areas of the stream, usually seeking pools formed by large woody debris or boulders (Hartman 1965) where they establish and defend feeding areas (Meehan 1991). These pools generally include structural components such as undercut banks and root masses, that not only provide cover from predators but shelter the fry from seasonal changes in flow and temperature (Meehan 1991). Coho fry feed primarily on aquatic insects, such as mayflies, caddisflies and chironomids, but also utilize terrestrial insects and earthworms (Groot and Margolis 1991).

REARING/OUT-MIGRATION

Coho generally rear in freshwater between 12 and 18 months, exhibiting a strong preference for structurally complex cover (McMahon and Hartman 1989) with off-channel pools for protection from high winter flows (Nickelson et al. 1992). Bustard and Narver (1975a, b) found that beaver ponds were an important overwintering area for juvenile coho, with a survival rate of roughly twice that of the entire stream system.

Out-migration begins in the spring, with the young moving rapidly through estuaries and out to sea. As smolts begin the ocean phase of their life, they usually travel through most, if not all, of the marine environments, including estuaries, nearshore habitat, and open ocean. During this time, coho tend to utilize the coastal waters, moving as far north as the Gulf of Alaska (Groot and Margolis 1991).

4-5.5 Population Trends

Catch records for coho have fluctuated cyclically in the past 30 years, but reached record low levels during the early 1990s (Johnson et al. 1997). In general, coho populations throughout the region are considered depressed from historic levels. In 1995, NOAA Fisheries named 6 ESUs for coho in the Pacific Northwest (Weitkamp et al. 1995). Of these, the 3 ESUs located in California and Oregon are considered to be in danger of extinction. The 3 ESUs located in Washington could become Threatened or Endangered in the future. The Puget Sound and Lower Columbia River/Southwest Washington ESUs are currently considered Candidates for listing as Threatened or Endangered under the Endangered Species Act. Although NOAA Fisheries could not reach a definite conclusion regarding the relationship of Clackamas River late-run coho salmon to the historic lower Columbia River ESU, they did conclude that the run is native and a remnant of the lower Columbia River ESU. It was determined that the stock was not currently in danger of extinction but could become so in the foreseeable future (Johnson et al. 1991).

LOWER COLUMBIA RIVER/SOUTHWEST WASHINGTON

Uncertainty about the affect of artificial propagation on the ancestry of the runs in this ESU prevented NOAA Fisheries from reaching a definite conclusion regarding the relationship between coho salmon in that area and the historical Lower Columbia River and Southwest Washington ESU (Weitkamp et al. 1995).

PUGET SOUND

For the Puget Sound ESU, NOAA Fisheries is concerned that if present trends continue, this ESU is likely to become Endangered in the foreseeable future. Although current population abundance is likely near historical levels and recent trends in overall population abundance have not been downward, there is substantial uncertainty relating to several of the risk factors including: widespread and intensive artificial propagation, high harvest rates, extensive habitat degradation, a recent dramatic decline in adult size, and unfavorable ocean conditions (Weitkamp et al. 1995).

OLYMPIC PENINSULA

Although there is continuing cause for concern about habitat destruction and hatchery practices within the Olympic Peninsula ESU, NOAA Fisheries concluded that there is sufficient native, natural, self-sustaining production of coho salmon that this ESU is not in danger of extinction and is not likely to become Endangered in the foreseeable future unless conditions change substantially (Weitkamp et al. 1995).

4-5.6 Assessment of Threats Warranting ESA Protection

Because juvenile coho can spend a significant portion of their lives in rivers and streams, they are particularly susceptible to human-induced changes in water quality or habitat degradation. In addition, adult spawning habitat is also subject to the negative impacts of land-use activities. Improper forest management, poor agricultural or grazing practices, or urban/suburban development can result in the loss or damage of critical coho spawning and rearing habitat. Common problems include modification of the natural hydrologic regime, non-point source pollution, and physical habitat destruction. Finally, adults and juveniles are affected by the presence of physical barriers to migration, including blocking culverts, dams and water-diversion structures, as well as by high temperatures or low-flow barriers.

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Habitat degradation and loss in freshwater, estuarine, and marine systems is thought to be a significant contributing factor to coho population declines in Washington and throughout the Pacific Northwest region (Weitkamp et al. 1995). Habitat degradation and loss has been linked to timber-harvest activities, agriculture and grazing and urbanization (Stouder et al. 1997). Hydroelectric dams and irrigation withdrawals have also been linked to the decline of coho populations, especially those in the Lower Columbia River (Johnson et al. 1991).

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Commercial and recreational fishing have been identified as a contributing factor in the decline of coho populations (Stouder et al. 1997).

DISEASE OR PREDATION

Neither disease nor predation has been identified as a significant threat to the species as a whole (Stouder et al. 1997).

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Geographically based harvest regulations that attempt to differentiate between hatchery and wild coho have been enacted, but it is not clear that these measures have been effective in protecting wild coho populations. It is also not clear whether current regulations governing land-use activities (timber harvest, agriculture and urban/suburban development) will be adequate to prevent further habitat degradation or loss.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Fish-passage barriers have long been a problem for coho, which often spawn in upper tributaries. Additionally, unfavorable climatic conditions during the last several years may have had a negative impact on marine survivability for coho.

4-5.7 Assessment of Potential Effects from Authorized Washington DNR Activities

Coho in the marine environment are not likely to be significantly affected by activities authorized by Washington DNR in saltwater environments because of their limited use of nearshore habitats. The areas of greatest concern are activities authorized in state-owned riverine habitat systems. Overwater structures provide a refuge for salmon predators and can destroy or prevent the formation of complex fry refuge habitat and alter food-web dynamics. Outfalls may cause localized reductions in water and sediment quality, resulting in increased turbidity, reduced foraging efficiency, diminished habitat quality and increased potential for the bioaccumulation of pollutants. The construction of roads and bridges may cause increased sedimentation during construction, and may increase temperature and pollutant loads from stormwater runoff during operation. Aquaculture operations may result in disease transmission, decreased dissolved oxygen levels and genetic dilution. They may also impact salmon through the increases in nitrogenous waste and the introduction of chemicals such as antifoulants, pesticides and antibiotics.

4-5.8 Species Coverage Recommendation and Justification

Coho salmon are recommended as a **Covered Species** primarily because: 1) Coho salmon are federally listed as Candidate Species; 2) Washington DNR authorized activities have a “high” potential to affect Coho salmon; and 3) Although information gaps exist, this species has been sufficiently studied to assess impacts and develop conservation measures.

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4-6 Sockeye Salmon

4-6.1 Species Name

Oncorhynchus nerka

Common Name: Sockeye salmon, kokanee, red salmon, blueback salmon

Initial coverage recommendation: Covered

4-6.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS (US FISH AND WILDLIFE, NOAA FISHERIES)

Evolutionarily Significant Unit	Status
Ozette Lake	Threatened (1999)
Snake River	Endangered (1991)
Baker River	Not Listed
Okanogan River	Not Listed
Lake Wenatchee	Not Listed
Quinalt Lake	Not Listed
Lake Pleasant	Not Listed

WASHINGTON FISH AND WILDLIFE STATUS

Population/Stock	State Status
Ozette Lake	State Candidate
Snake River	State Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Population	Global Rank
Snake River	G5, T1Q
Ozette Lake	G5, T2Q

NATURAL HERITAGE PROGRAM STATE RANK

Population	State Rank
Snake River	S?
Ozette Lake	S?

4-6.3 Range

The historical range of sockeye salmon is thought to be close to their current range (Burgner 1991; Gustafson et al. 1997; Wydoski and Whitney 2003). The species naturally occurs from Alaska through British Columbia and into Washington and Idaho, as far south as the Columbia River system. Sockeye occur in an anadromous and a landlocked form, which is referred to as kokanee.

The Washington Department of Fish and Wildlife recognizes nine sockeye salmon stocks in the state, with the two largest runs occurring in Lake Washington (three stocks) and the Columbia River (two stocks). Sockeye are found throughout the state in the Snake, Okanogan, Lake Wenatchee, Lake Quinault, Lake Ozette, Baker River, Lake Pleasant and Big Bear Creek drainages. The landlocked form of sockeye (Kokanee) occurs in many lakes throughout Washington, with some of the larger populations in Banks and Loon Lakes in eastern Washington, and Lake Whatcom and Lake Washington-Sammamish in western Washington (Wydoski and Whitney 2003). A figure representing the freshwater distribution of sockeye salmon (including kokanee) in Washington may be found in Appendix F.

4-6.4 Habitat Use

ADULT

Sockeye is one of the most complex of any Pacific salmon species because of its variable freshwater residency (1 to 3 years), and because the species has several different forms. While most sockeye are anadromous and spawn in rivers or lakes, some remain in freshwater throughout their life span (Wydoski and Whitney 2003). Anadromous forms stay at sea for 2 to 4 years, reaching a maximum length of 83 centimeters and weighing between 1.5 and 3.5 kilograms at maturity, whereas landlocked forms are generally smaller (lengths 20 to 40 centimeters) (Wydoski and Whitney 2003). Adult diet varies by life form, with ocean populations being generally piscivorous and landlocked forms consuming zooplankton and aquatic and terrestrial insects (Wydoski and Whitney 2003).

SPAWNING/INCUBATION/EMERGENCE

Sockeye salmon exhibit the greatest diversity in selection of spawning habitat, river entry timing and the duration of holding in lakes prior to spawning among the Pacific salmon. Although the species typically spawns in inlet or outlet tributaries of a nursery lake, they may also spawn in 1) suitable habitat between lakes; 2) along the shore of nursery lakes on tributary outwash fans or submerged beaches where groundwater upwelling occurs; 3) along beaches where the gravel or rocky substrate is free of fine sediment and the eggs can be oxygenated by wind-driven circulation; or 4) in mainstem rivers without juvenile lake-rearing habitat (Burgner 1991).

Adult sockeye salmon home precisely to their natal stream or lake habitat (Hanamura 1966; Quinn 1984; Quinn et al. 1987), with stream fidelity thought to be adaptive,

ensuring that juveniles will encounter a suitable nursery lake. Spawning begins as early as August, with some stocks spawning into February. Similarly to other salmonids, sockeye require well-oxygenated riffles with egg and alevin survivals dependent on clean spawning gravels and low-to-moderate winter stream flows.

The species adaptation to utilizing lacustrine environments for both adult spawning and juvenile rearing has resulted in the evolution of complex timing for incubation, fry emergence, spawning and adult lake entry that often involves intricate patterns of adult and juvenile migration and orientation not seen in other *Oncorhynchus* species (Burgner 1991).

At a constant temperature of 10° Celsius, sockeye salmon had the longest incubation period to 50 percent hatch of five salmon species tested. Benefits of inter-gravel incubation include protection from predation, freezing, fluctuating flows and desiccation. Survival during incubation is influenced by environmental conditions, the degree of crowding during spawning (Burgner 1991), the type of gravel in which eggs are laid, and the gravel's permeability to water (Burgner 1991).

REARING/OUT-MIGRATION

Sockeye migrate downstream to the deep waters of nursery lakes upon emergence from spawning sites, at a size of approximately 25 to 32 millimeters (1.0 to 1.26 inches). At this small size, sockeye fry are vulnerable to predation by other fishes and birds, and survivals can be lowered substantially by aggregations of predators. Cool, clean water is essential for the survival of sockeye during freshwater rearing, with water temperatures greater than 20° Celsius impairing growth rates if adequate food is not available (Meehan 1991). Higher growth rates not only reduce the species vulnerability to predators, but also have a direct affect on survival rates of anadromous forms (Washington Fish and Wildlife 2005).

Growth influences the duration of stay in the nursery lake and is influenced by intra- and inter-specific competition, food supply, water temperature, thermal stratification, migratory movements to avoid predation, lake turbidity and by the length of the growing season. Lake residence time is usually greater the farther north a nursery lake is located. In Washington and British Columbia, lake residence is normally 1 or 2 years, whereas in Alaska, some fish may remain 3, or rarely 4, years in the nursery lake prior to smoltification (Burgner 1991).

Juvenile sockeye typically rear for 1 to 3 years in lake habitats, with anadromous forms out-migrating, and Kokanee continuing their lake residency and becoming sexually mature at ages 2 to 3 years (Wydoski and Whitney 2003). The offspring of riverine spawners generally rear for 1 to 2 years in lower slow-velocity sections of rivers (river-type), although some populations migrate to estuarine environments after a few months in their natal stream (sea-type) (Burgner 1991). Out-migrating lake-type sockeye typically migrate to the estuary between 1 and 3 years of age (Burgner 1991).

Juvenile sockeye salmon spend the first part of their marine lives in estuarine and nearshore areas adjacent to their natal streams, although their residence time in these areas may be the shortest for any of the salmon species. Smolt migration begins in late April, with southern stocks migrating earliest. Northward migration of juveniles to the Gulf of Alaska occurs in a band relatively close to shore, and offshore movement of

juveniles occurs in late autumn or winter. Sockeye salmon prefer cooler ocean conditions than do other Pacific salmon (Burgner 1991).

4-6.5 Population Trends

Catch records for sockeye have fluctuated cyclically during the last 30 years, but reached record low levels during the last decade (Stouder et al. 1997). In general, sockeye populations throughout the region are considered depressed from historic levels. NOAA Fisheries has identified seven individual ESUs for sockeye in Washington (Gustafson et al. 1997), with two of these ESUs considered to be in danger of or Threatened with extinction (Snake River and Ozette Lake).

4-6.6 Assessment of Threats Warranting ESA Protection

Because juvenile sockeye can spend a significant portion of their lives in rivers, streams and lakes, they are particularly susceptible to human-induced degradation of water quality and habitat. In addition, adult spawning habitat is also subject to the negative impacts of land-use activities such as logging, agricultural, grazing, and urban/suburban development. Common problems include modification of the natural hydrologic regime, non-point-source pollution and physical habitat destruction. Finally, adults and juveniles are affected by the presence of physical barriers to migration, including blocking culverts, dams, water-diversion structures and low-flow barriers, as well as by high temperatures.

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Habitat degradation and loss in freshwater, estuarine and marine systems is thought to be a significant contributing factor to sockeye population declines throughout the Pacific Northwest region. Of particular concern is lakeshore development or other human activities that degrade lake ecosystems that support sockeye and/or Kokanee populations (Gustafson et al. 1997). Habitat degradation and loss has been linked to timber-harvest activities, agriculture and grazing, and urbanization (Stouder et al. 1997). Hydroelectric dams and irrigation withdrawals have also been linked to the decline of salmon populations in general, especially those in the Columbia River Basin (Stouder et al. 1997).

Channelization and bank armoring reduces the amount, quality and diversity of sockeye spawning areas by narrowing and deepening the stream channel. Those sockeye that spawn on lakeshores need access to undisturbed, shallow-water shorelines and clean gravels with upwelling ground water (Washington Fish and Wildlife 2005).

The erosion and downstream movement of spawning gravels is a major cause of egg and alevin losses, and severe flooding can cause mortalities exceeding 90 percent. Land-use practices and natural events that introduce substantial amounts of silt into spawning streams affect sockeye inter-gravel survivals by reducing the permeability of the gravel,

which can affect the survival of incubating eggs and alevins by interfering with the delivery of oxygenated water and the removal of metabolic wastes.

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Fishing pressure (commercial and recreational) has been identified as a contributing factor in the decline of sockeye populations (Gustafson et al. 1997). Although catch records have been used to manage sockeye abundance throughout the Pacific Northwest, the inherent geographic and genetic variability of the harvest composition may result in the over harvesting of specific stocks.

DISEASE OR PREDATION

Neither disease nor predation has been identified as a significant threat to the species as a whole (Stouder et al. 1997). However, predation on migrating sockeye salmon fry varies considerably with spawning location (lakeshore beach, creek, river or spring area). Sockeye salmon fry mortality due to predation by other fish species and birds can be extensive during downstream and upstream migration to nursery lake habitat and is only partially reduced by the nocturnal migratory movement of some fry populations (Burgner 1991).

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Existing regulatory mechanisms attempt to differentiate between hatchery and wild stock harvests, and include geographic regulations such as specific river drainages. However, it is not clear that these measures have been effective in protecting sockeye and Kokanee populations. In addition, current harvest regulations also may not be adequate to protect these fish. Finally, it is not clear whether current regulations governing land-use activities (timber harvest, agriculture and urban/suburban development) will be adequate to prevent further habitat degradation or loss.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Fish-passage barriers are a potential problem for sockeye and Kokanee, which often utilize lake tributaries to spawn. Additionally, unfavorable climatic conditions during the last several years may have negatively affected marine survivability for sockeye.

4-6.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Sockeye and Kokanee populations are likely to be affected by activities authorized by Washington DNR on state-owned riverine, lake and nearshore-estuarine systems. Outfalls may increase eutrophication, siltation and water temperature warming in cold, oligotrophic, deepwater lake habitats. Over-water structures (e.g., boat ramps/launches, jetties) may alter shallow-water habitats. Nearshore and transportation related activities (e.g., fill and bank armoring, sediment disturbance, utility line construction) could alter shallow-water lake and stream tributary habitats. Aquaculture operations may cause

disease transmission, decreased dissolved oxygen levels and genetic dilution. They may also impact salmon through the increases in nitrogenous waste and the introduction of chemicals such as antifoulants, pesticides and antibiotics.

4-6.8 Species Coverage Recommendation and Justification

It is recommended that sockeye and Kokanee be addressed as a **Covered Species** for the following reasons: 1) The species is currently listed under the ESA and the present or Threatened destruction, modification or curtailment of its habitat or range is significant; 2) Washington DNR authorized activities have a “high” potential to affect sockeye and Kokanee; and 3) Although information gaps exist, sockeye have been sufficiently studied to assess impacts and develop conservation measures.

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4-7 Steelhead

4-7.1 Species Name

Oncorhynchus mykiss

Common Name: Steelhead

The steelhead is the state fish of Washington.

Initial coverage recommendation: Covered

4-7.2 Status and Rank

Steelhead trout have been identified as Threatened or Endangered in Washington primarily because of habitat degradation or loss, along with overharvesting and competitive pressures from hatchery stocks (NOAA Fisheries 1996). The National Oceanic and Atmospheric Administration Fisheries recognizes 15 ESUs of steelhead, several of which occur in Washington. See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS (NOAA FISHERIES 2005)

Population	Status
Middle Columbia River	Threatened (1999)
Upper Columbia River	Endangered (1997)
Snake River Basin	Threatened (1997)
Lower Columbia River	Threatened (1998)
Southwest Washington	Not Listed
Olympic Peninsula	Not Listed
Puget Sound	Not Listed

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Population	Status
Lower Columbia River	Candidate
Middle Columbia River	Candidate
Upper Columbia River	Candidate
Snake River Basin	Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Population	Global Rank
Upper Columbia River	G5, T2Q
Snake River Basin	G5, T2T3
Lower Columbia River	G5, T2Q
Middle Columbia River	G5, T2Q
Southwest Washington	G5, T3Q

NATURAL HERITAGE PROGRAM STATE RANK

Population	State Rank
Upper Columbia River	S?
Snake River Basin	S?
Lower Columbia River	S?
Middle Columbia River	S?
Southwest Washington	S?

4-7.3 Range

Currently, steelhead trout occur naturally from Alaska through British Columbia, Washington, Oregon, California and Idaho. The historic range is thought to be from northern Mexico to Alaska in most rivers with access to the Pacific Ocean (Groot and Margolis 1991; Busby et al. 1996; Wydoski and Whitney 2003). Steelhead trout have also been introduced worldwide, becoming naturalized in many areas with rainbow trout, the non-anadromous form of steelhead.

Steelhead populations in Washington occur in the Upper, Lower and Middle Columbia River, Puget Sound, on the Olympic Peninsula, in southwest Washington and the Snake River Basin. A figure representing the freshwater distribution of steelhead in Washington may be found in Appendix F.

4-7.4 Habitat Use

ADULT

During their ocean phase of life, steelhead range from Alaska to Japan (McKinnell et al. 1997) and are generally found within 16 to 40 kilometers (10 to 25 miles) of the shore (Wydoski and Whitney 2003). Steelhead remain in the marine environment 2 to 4 years and attain lengths of approximately 0.6 meters, with weights ranging from 2.5 to 5 kilograms (Wydoski and Whitney 2003). Although the species is mainly piscivorous feeding on juvenile rockfish (*Sebastes* spp.), sand lance (*Ammodytes hexapterus*), sculpin (Cottidae), and greenlings (Hexagrammidae) they also feed on invertebrates, especially euphausiids, amphipods, copepods and squid (Groot and Margolis 1991). Unlike most other salmonids, steelhead are iteroparous - capable of spawning more than once and adults return to the ocean after spawning (Wydoski and Whitney 2003).

SPAWNING/INCUBATION/EMERGENCE

Most steelhead spawn at least twice in their lifetimes with many returning to spawn three or four times (Wydoski and Whitney 2003). However, in larger rivers where steelhead travel long distances to their natal spawning grounds, the proportion of returning adults who spawn more than once is considerably lower (Meehan 1991). While steelhead typically spawn in the spring, there are two runs: a summer run that enters freshwater in August and September, and a winter run that occurs from December through February (Wydoski and Whitney 2003).

Spawning behavior is similar to other salmonids, with females digging redds in cold, well-oxygenated waters where there are gravel substrates (Groot and Margolis 1991; Wydoski and Whitney 2003). Escape cover, such as logs, undercut banks and deep pools are also important for adult and young steelhead (Meehan 1991).

The length of time it takes for eggs to hatch is heavily dependent on water temperature, and under controlled conditions, steelhead eggs usually hatch after about 30 days at a temperature of 10° Celsius. Although eggs hatch sooner in warmer water, the young fish are smaller and generally have lower survival rates. If the temperature goes too high, eggs will not hatch at all (Groot and Margolis 1991).

After hatching, alevins typically remain in the gravel for another 4 to 6 weeks, obtaining nutrients from the yolk sack attached to their body. When they emerge from the gravel as fry, the young move to shallow, protected areas at the stream margins where they establish and defend feeding areas. Most juveniles can be found in riffles, although larger ones will move to pools or deep runs (Meehan 1991).

REARING/OUT-MIGRATION

Cool, clean water is essential for the survival of steelhead during all portions of their freshwater rearing. Warmer water (>20° Celsius) not only can impair growth rates by reducing food supplies, but also holds less dissolved oxygen and increases the steelhead's susceptibility to disease (Meehan 1991).

Steelhead may rear in freshwater for up to 4 years before migrating to sea, although the most common pattern for fish in Washington is 2 years in fresh water followed by 2 years at sea before spawning (Busby et al. 1996). This species can use all types of freshwater riverine habitat for rearing, but prefers faster water (e.g., riffles or runs) than Coho and Chinook salmon rearing in the same streams (Meehan 1991).

During their first summer, juvenile steelhead are typically found at the downstream end of relatively shallow areas with cobble and boulder bottoms or in riffles less than two feet deep (Meehan 1991). Similar to other species of salmonids, juveniles generally prefer areas that include large woody debris, root wads and/or boulders as cover from predators and as protection from both high and low stream-flow events. As juvenile steelhead grow, pools with an abundance of escape cover become more important as habitat (Stouder et al. 1997). Young-of-the-year steelhead feed primarily on aquatic insects, such as mayflies, caddisflies and chironomids, although terrestrial invertebrates are also considered important prey (Groot and Margolis 1991). Out-migrating smolts typically leave their natal streams between 2 and 4 years of age (Groot and Margolis 1991).

traveling through most, if not all, of the marine environments, including estuaries, nearshore habitat and open ocean.

4-7.5 Population Trends

In general, steelhead populations throughout the region are considered depressed from historical levels, with 5 of the 15 ESUs in the Pacific Northwest considered to be in danger of extinction and 4 others considered Threatened or likely to become Endangered (NOAA Fisheries 1996). Populations for the seven stocks occurring in Washington are:

PUGET SOUND

Recent population trends within the Puget Sound ESU are predominantly decreasing; however, trends in the two largest stocks (Skagit and Snohomish Rivers) have been increasing (Busby et al. 1996).

OLYMPIC PENINSULA

Although population trends for Olympic Peninsula steelhead are generally increasing, some stocks appear to be declining and there is also uncertainty regarding the degree of interaction between hatchery and natural stocks (Busby et al. 1996).

SOUTHWEST WASHINGTON

This ESU occupies the tributaries to Grays Harbor, Willapa Bay and the Columbia River below the Cowlitz River in Washington (including the Grays River basin). Most population trends within this ESU have been declining and there is also uncertainty regarding the degree of interaction between hatchery and natural stocks (Busby et al. 1996).

LOWER COLUMBIA

The Lower Columbia ESU occupies tributaries to the Columbia River between the Cowlitz and Wind Rivers in Washington. While most of the stocks in this ESU for which data exists have been declining, others have been increasing strongly (Busby et al. 1996).

MIDDLE COLUMBIA

The Middle Columbia River ESU occupies the Columbia River Basin from above the Wind River in Washington and the Hood River in Oregon upstream to the Yakima River. Some uncertainty exists about the exact boundary between coastal and inland steelhead, and the western margin of this ESU reflects currently available genetic data. Most natural stocks for which we have data within this ESU have been declining (Busby et al. 1996).

UPPER COLUMBIA

The Upper Columbia ESU occupies the Columbia River Basin upstream from the Yakima River. Total abundance of populations within this ESU has been relatively stable or increasing; however, this trend appears to be primarily a result of major hatchery

supplementation programs. The major concern for this ESU is the clear failure of natural stocks to be self-sustaining. (Busby et al. 1996).

SNAKE RIVER BASIN

This ESU occupies the Snake River Basin of southeast Washington, northeast Oregon and Idaho. The majority of natural stocks for which we have data within this ESU have been declining (Busby et al. 1996).

4-7.6 Assessment of Threats Warranting ESA Protection

Because juvenile steelhead spend a significant portion of their lives in rivers and streams, they are particularly susceptible to human-induced degradation of water quality and habitat. In addition, adult spawning habitat is also subject to the negative impacts of land-use activities such as logging, agricultural, grazing, and urban/suburban development. Common problems include modification of the natural hydrologic regime, non-point-source pollution and physical habitat destruction. Finally, adults and juveniles are affected by the presence of physical barriers to migration, including blocking culverts, dams, water-diversion structures and low-flow barriers, as well as by high temperatures.

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Habitat degradation and loss in freshwater, estuarine and marine systems is thought to be a significant contributing factor to steelhead population declines in Washington and throughout the Pacific Northwest region (Busby et al. 1996). Habitat degradation and loss has been linked to timber harvest activities, agriculture, grazing, and urbanization (Stouder et al. 1997). Hydroelectric dams and irrigation withdrawals have also been identified as causal (Stouder et al. 1997).

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC, OR EDUCATIONAL PURPOSES

Fishing pressure (commercial and recreational) has been identified as a contributing factor in the decline of steelhead populations (Stouder et al. 1997).

DISEASE OR PREDATION

Neither disease nor predation has been identified as a significant threat to the species as a whole (Stouder et al. 1997).

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Existing regulatory mechanisms attempt to differentiate between hatchery and wild stock harvests, and include geographic regulations such as specific river drainages. However, it is not clear that these measures have been effective in protecting steelhead populations. In addition, current harvest regulations also may not be adequate to protect these fish. Finally, it is not clear whether current regulations governing land-use activities (timber

harvest, agriculture and urban/suburban development) will be adequate to prevent further habitat degradation or loss.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Fish passage barriers have long been a problem for steelhead, which often use upper tributaries to spawn. Additionally, unfavorable climatic conditions during the last several years may have negatively affected marine survivability for steelhead.

4-7.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Although steelhead do not extensively use nearshore habitats, they may be affected by activities authorized by Washington DNR occurring in state-owned riverine habitats. Outfalls may cause localized reductions in water and sediment quality, resulting in increased turbidity, reduced foraging efficiency, diminished habitat quality and increased potential for the bioaccumulation of pollutants. Over-water structures (e.g., boat ramps/launches, jetties) may alter shallow-water habitats. The construction of roads and bridges may result in increased sedimentation during construction, and may increase temperature and pollutant loads from stormwater runoff during operation. Aquaculture operations may result in disease transmission, decreased dissolved oxygen levels and genetic dilution. They may also impact salmon through the increases in nitrogenous waste and the introduction of chemicals such as antifoulants, pesticides and antibiotics.

4-7.8 Species Coverage Recommendation and Justification

It is recommended that steelhead be addressed as a **Covered Species** for the following reasons: 1) Four of the seven steelhead ESUs occurring in Washington are currently listed as Threatened or Endangered under the ESA; 2) Washington DNR authorized activities have a “high” potential to affect steelhead; and 3) Sufficient information exists to assess impacts and develop conservation measures.

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4-8 Eulachon

4-8.1 Species Name

Thaleichthys pacificus

Common Name: Eulachon, candlefish, Columbia River smelt

Initial coverage recommendation: Covered

4-8.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not listed

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Candidate (2004)

NATURAL HERITAGE PROGRAM GLOBAL RANK

G5

NATURAL HERITAGE PROGRAM STATE RANK

S3

4-8.3 Range

Eulachon naturally occur from the Pribilof Islands in the Bering Sea south to Monterey Bay, California (Eschmeyer and Herald 1983). They are anadromous and are found in the nearshore zone, coastal inlets and rivers. Information regarding the geographic distribution of eulachon is incomplete, therefore no species distribution map is presented for this species.

In Washington, eulachon spawn in the Columbia River below Bonneville Dam and in the Cowlitz, Grays, Kalama, Lewis, Sandy and Nooksack Rivers (Wydoski and Whitney 2003). These fish are important prey items for many species of fish, marine mammals and birds along the Pacific coast.

4-8.4 Habitat Use

Adult

Eulachon are found in inshore marine waters throughout the Pacific Ocean at depths of 80 to 200 meters. The species is pelagic and is not associated with a particular substrate or habitat type, except during periods of spawning. Eulachon become sexually mature at 2 to 5 years of age, with average lengths ranging between 7 and 12 centimeters (Wydoski and Whitney 2003). Despite its widespread occurrence, very little is known about eulachon during its saltwater phase, except that they are known to prey heavily on euphausiid shrimp in shallow waters (Wydoski and Whitney 2003) and are often bycatch in the shrimp fishery. Eulachon use only 20 to 30 river systems on the west coast for spawning (Canadian Department of Fisheries and Oceans 2004) and spawning runs have been identified as critical feeding opportunities for marine mammals as well as several species of fish and birds, because of the eulachon's high energy content (Wydoski and Whitney 2003; Sigler et al. 2004).

SPAWNING/INCUBATION / EMERGENCE

Eulachon return to fresh water to spawn from December until March, with peak spawning activity in Washington occurring in February and March (Wydoski and Whitney 2003). Eulachon are broadcast spawners, generally spawning in lower gradient reaches with coarse sediments (McLean et al. 1999). Although timing is highly dependent on river conditions, eulachon prefer to spawn in systems with strong freshets (Canadian Department of Fisheries and Oceans 2004) with spawning generally occurring at night (Wydoski and Whitney 2003). Eulachon are thought to die after spawning, generally washing out to the ocean or being consumed locally by birds, mammals and fish, such as sturgeon (Wydoski and Whitney 2003).

Hatching occurs within 2 to 3 weeks, with the larvae passively washed downstream to the ocean (McClellan et al. 1999).

REARING / OUTMIGRATION

Though anadromous, eulachon spend no time rearing in fresh water as larvae and juveniles. Once in the marine environment, postlarval eulachon are neritic and stay near the surface of the water, feeding on copepod larvae in both the nearshore and offshore ecosystems. Prey items range from phytoplankton to copepods, Cladocera and euphausiids, with larger eulachon eating larvae of their own species (Hart 1973).

4-8.5 Population Trends

Populations of eulachon have declined drastically in the last decade and although the cause is unknown, unfavorable ocean conditions, overharvesting and habitat loss are thought to have played a part. Although stock assessments have not been conducted, commercial harvest data for the Columbia River have been kept since the 1930s (Bargmann 1998) and the 5 year average catch has declined from almost 900 tons during

1990 to 1994, to less than 75 tons for 1995 to 1997 (Wydoski and Whitney 2003) . While harvest data is largely market driven and may not reflect population size, the declining trend is notable. Stock assessments have been conducted in British Columbia and show that populations have declined since the late 1980s, with the Fraser River showing a decline over the last decade similar to that for the Columbia River (Canadian Department of Fisheries and Oceans 2004).

4-8.6 Assessment of Threats Warranting ESA Protection

Destruction, Modification, or Curtailment of Habitat or Range

The destruction or alteration of spawning habitats is of concern and dredging for the maintenance of shipping lanes may be detrimental to spawning habitat in the Columbia River and other navigable waterways,.

Over-utilization for Commercial, Recreational, Scientific or Educational Purposes

Eulachon are harvested commercially and recreationally by using gillnets, dip nets and trawls and are noted as a significant bycatch in the shrimp fishery. Overharvest has resulted from targeted recreational and commercial activities.

Disease or Predation

Neither disease nor predation has been identified as a significant threat to the species.

Adequacy of Existing Regulatory Mechanisms

Although the Washington Department of Fish and Wildlife has a forage fish management plan (Bargmann 1998), a harvest management plan has not been established for eulachon.

Other Factors Affecting Continued Existence

Global climate change and oceanic conditions may have contributed to the recent reduction of eulachon in Washington and British Columbia.

4-8.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Eulachon are dependent on freshwater ecosystems for reproduction and the marine nearshore zone for their early life history. Any Washington DNR activity that could negatively impact the riparian corridor could in turn negatively affect the eulachon population. Authorized activities, such as overwater structures, nearshore activities (such as the construction of piers, docks and marinas) and multiple or complex structures, could affect the migration to and from spawning grounds. Additionally, alterations to the substrate itself (via increased/decreased sediment transport, dredging and filling) will

have negative impacts on eulachon spawning, because reproductive success is highly dependent on suitable sediment.

4-8.8 Species Coverage Recommendation and Justification

Eulachon should be considered a **Covered Species** for the following reasons: 1) The species is not federally listed, but it is a candidate for listing by the State of Washington; 2) There is a “high” potential for Washington DNR authorized activities to affect the eulachon; and 3) Insufficient information exists regarding the distribution of eulachon to assess impacts and to develop conservation measures.

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4-9 Green Sturgeon

4-9.1 Species Name

Acipenser medirostris

Common Name: Green sturgeon

Initial coverage recommendation: Watch-list

4-9.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

The National Oceanic and Atmospheric Administration (NOAA) Fisheries denied listing under the Endangered Species Act for the green sturgeon northern distinct population segment (DPS) (all populations from the Eel River in California northward) and the southern DPS (essentially the Sacramento River population) in 2003 but considers it a Candidate Species (Adams et al. 2002; 50 C.F.R. 223-224, 2003).

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Not listed

NATURAL HERITAGE PROGRAM GLOBAL RANK

G3

NATURAL HERITAGE PROGRAM STATE RANK

S2N

4-9.3 Range

Range-wide, green sturgeon occur in nearshore marine habitats along the Pacific coast from Ensenada, Mexico, north to southeastern Alaska (Wydoski and Whitney 2003). An anadromous species, the green sturgeon spends more time in the ocean than any other sturgeon, but occurs seasonally in the lower reaches of larger rivers and estuaries (Adams et al. 2002; Wydoski and Whitney 2003). Reproductive populations of green sturgeon currently occur in the Sacramento, Klamath and Rogue Rivers, and were historically

thought to spawn in the Eel, Umpqua and South Fork of the Trinity River (Adams et al. 2002).

Green sturgeon are present in all marine areas of Washington State, with minor catches occurring in Puget Sound and coastal Washington. Concentrations of green sturgeon are found during the summer in Willapa Bay, Grays Harbor and the lower 60 miles of the Columbia River (to Bonneville Dam) (Adams et al. 2002). Green and white sturgeon have also been observed concentrating in some tributaries (e.g., Salmon Creek in Discovery Bay) of Puget Sound / Strait of Juan de Fuca (Johnson, Personal communication. March 16, 2005). However, information regarding the geographic distribution of green sturgeon in Washington State is incomplete, therefore no species distribution map is presented for this species.

4-9.4 Habitat Use

ADULT

Like all sturgeon species, green sturgeon are characterized by their large size, longevity, delayed maturation, high fecundity and slow growth. Adults are estimated to live for up to 60 years and reach a maximum length of 2.1 meters and 136 kilograms (Hart 1988; Emmett et al. 1991). As adults they are tolerant of a wide range of salinities and spend most of their life in nearshore marine waters and estuaries (Emmett et al. 1991). Green sturgeon are anadromous, with adults residing in subtidal areas and appearing to move from coastal marine waters into estuaries and rivers to feed and spawn (Emmett et al. 1991).

Green sturgeon have a ventral, protrusible mouth that is adapted to feeding over unconsolidated sediments; prey include benthic and epibenthic invertebrates (e.g., shrimp, mollusks, amphipods) and small fish, such as Pacific sand lance (Hart 1988; Adams et al. 2002; Wydoski and Whitney 2003). The species life history, habits, age, and growth have not been studied extensively (Emmett et al. 1991; Wydoski and Whitney 2003), although the proposed federal listing has spurred a number of recent research projects designed to clarify ecological and biological questions (Beamesderfer and Webb 2002; Farr and Rien 2002).

Some individuals travel extensive distances in the ocean, with fish tagged in the Sacramento-San Joaquin estuary being collected from the Columbia River and Grays Harbor one to three years later (Emmett et al. 1991). Tagging studies suggest that many immature green sturgeon migrate north from their natal rivers in California and Oregon, and concentrate in Washington and Oregon coastal estuaries during the summer (Adams et al. 2002). Reasons for these seasonal concentrations are unclear, as there is no documented spawning in these systems and stomachs are generally empty.

SPAWNING

While there are no documented spawning locations for green sturgeon within Washington State; spawning locations currently exist within the Sacramento, Klamath and Rogue Rivers. In these systems, adults migrate into rivers to spawn during March to July, with a peak in mid-April to mid-June. Green sturgeon males reach sexual maturity at 15 to 30 years of age, and females mature at 17 to 40 years (Adams et al. 2002). Spawning is thought to be episodic, occurring once every 3 to 5 years (Adams et al. 2002), and annual success likely varies greatly depending on conditions (Beamesderfer and Webb 2002). Adult green sturgeon broadcast spawn in deep areas with swift current and substrate ranging from clean sand to bedrock (Emmett et al. 1991), although the relatively nonadhesive eggs are most likely broadcast over large cobble, where they settle into crevices and interstitial spaces until hatching (Adams et al. 2002). Female green sturgeon have relatively low fecundity compared with other sturgeon species, and produce 60,000 to 140,000 eggs (Adams et al. 2002).

INCUBATION / EMERGENCE / LARVAE

Temperatures above 20° Celsius are lethal to green sturgeon eggs in the laboratory (Adams et al. 2002). It is unclear from the literature what the flow requirements are for incubation; however, time to hatching has been estimated to be 196 hours at 12.7° Celsius for similar species (Emmett et al. 1991). Green sturgeon larvae are fast-growing and robust, with optimal laboratory growth rates observed at 15° Celsius (Adams et al. 2002). Larvae are also photonegative and appear to be nocturnal, potential adaptations for avoiding downstream displacement and predation (Adams et al. 2002). Larvae begin to exhibit feeding behavior at about 10 days post-hatch, and metamorphose to juveniles in freshwater riverine habitats at approximately 2.0 centimeters in 45 days (Emmett et al. 1991).

EARLY JUVENILE

Juvenile green sturgeon are common in tidal freshwater areas of their natal rivers, and migrate out to nearshore marine waters between one and four years of age (Emmett et al. 1991). They grow rapidly (to 300 millimeters in one year) on a diet of benthic invertebrates, such as amphipods and mysid shrimp (Adams et al. 2002; Wydoski and Whitney 2003). Juvenile green sturgeon are often found in shallow water (1 to 3 meters deep), and may forage over tidal flats (Emmett et al. 1991).

The scientific literature generally does not distinguish any differences between habitat use by older, sexually immature green sturgeon and adults (see adult section).

4-9.5 Population Trends

Two green sturgeon DPSs were identified based on preliminary genetic evidence and spawning site fidelity: 1) the northern DPS, encompassing all populations from the Eel River, in northern California, northward, and 2) the southern DPS, including all populations south of the Eel River (essentially the Sacramento River population) (Adams et al. 2002).

Researchers recently concluded that there is not adequate population abundance or trend data to assess the population status of green sturgeon (Adams et al. 2002; 50 C.F.R. 223-224, 2003). Because green sturgeon are not a targeted fishery, all harvest data are based on bycatch from white sturgeon and tribal salmon gillnet fisheries; only one nonharvest population estimate is made and it is based on incidental monitoring of white sturgeon populations. Taken together, the data may suggest that green sturgeon harvest has declined in recent years while average green sturgeon size has increased. However, these data time series suffer from changing regulations and effort levels, and no analysis resulted in significant abundance trends (Adams et al. 2002). The National Marine Fisheries Service biological review team did conclude that green sturgeon in each DPS “faced considerable threats to their populations” and “should be placed on the Candidates list and have their status reviewed within five years” (Adams et al. 2002). These findings were especially relevant to the much smaller southern DPS, for which summer temperatures in the Sacramento River approach the lethal limits for larvae.

However, it should be noted that in an independent review of the same information, Beamesderfer and Webb (2002) suggest that green sturgeon abundance may be increasing primarily based on their interpretation of Columbia River harvest data and apparent increasing trends in average size. They suggest that increasing trends in average size are a result of decreasing recruitment or mortality; however, these suggestions are not the only explanation for these trends, and warrant more critical evaluation.

4-9.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

The loss and/or destruction of critical spawning habitat are of utmost concern in the decline of green sturgeon, which are concentrated in three significant spawning locations (Adams et al. 2002). The concentration of these physically unique spawning locations (high flow, deep water, specific substrate characteristics) makes green sturgeon vulnerable to possible catastrophic events. This is especially relevant to the southern DPS in the Sacramento River, which has a number of state and federal water-diversion facilities that entrain juvenile sturgeon as water is withdrawn from the Sacramento-San Joaquin Delta. Dam operation and land-use practices may also affect green sturgeon spawning habitat.

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Although the green sturgeon is not specifically targeted in many commercial, tribal, or recreational fisheries because of the inferior quality of its flesh and eggs (Wydoski and Whitney 2003), there are concerns because it is commonly harvested as bycatch in those fisheries targeting more highly prized white sturgeon and salmon (Adams et al. 2002).

DISEASE OR PREDATION

Neither disease nor predation has been identified a significant threat to the species as a whole.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Current population abundance and trend data are inadequate to assess green sturgeon population status (Adams et al. 2002), and it is therefore not possible to determine the adequacy of existing regulatory mechanisms. While some authors have suggested that management activities designed to protect white sturgeon have incidentally benefited green salmon (Beamesderfer and Webb 2002), this observation highlights the problem that green sturgeon catch often falls under the umbrella of the white sturgeon regulations.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Additional threats especially relevant to green sturgeon in the southern DPS include potentially lethal temperature limits for larvae, juvenile entrainment by water projects and bioaccumulation of toxic materials such as polychlorinated biphenyls (PCBs) (Adams et al. 2002).

4-9.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Green sturgeon in the offshore environment are not likely to be affected by most activities authorized on state-owned aquatic lands by Washington DNR. Areas of concern include activities authorized within the estuarine and freshwater habitat systems of Grays Harbor, Willapa Bay, the lower Columbia River and some areas of Puget Sound, where concentrations of green sturgeon are found during the summer. Discharges from outfalls and runoff from impervious surfaces (roads, docks) may contribute toxic contaminants to aquatic habitats used by sturgeon. Activities that alter feeding and rearing habitats, such as shellfish aquaculture in tidal flats and sediment disturbance associated with mining and dredging activities, may adversely impact green sturgeon. Green sturgeon may be affected by invasive-species control activities that affect prey species (e.g., benthic and epibenthic invertebrates).

4-9.8 Species Coverage Recommendation and Justification

It is recommended that green sturgeon be addressed as an **Evaluation Species** because: 1) The green sturgeon is currently considered a federal Candidate Species, with a status review to be conducted in 2007; 2) Washington DNR authorized activities have a “medium” potential to affect Green sturgeon; and 3) Sufficient information is available to assess impacts and to develop conservation measures.

4-9.9 References

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4-10 Pacific Lamprey

4-10.1 Species Name

Lampetra tridentata

Common Name: Pacific lamprey

Initial coverage recommendation: Covered

4-10.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Species of Concern

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Not Listed

NATURAL HERITAGE PROGRAM GLOBAL RANK

G5

NATURAL HERITAGE PROGRAM STATE RANK

S3, S4

4-10.3 Range

The Pacific lamprey ranges from Baja California to the Aleutian Islands in Alaska (Wydoski and Whitney 2003). They are also found along the eastern Asia coast as far south as Japan.

Within Washington State, the Pacific lamprey is found in most large rivers and streams along the coast, Strait of Juan de Fuca, and Puget Sound, and occurs far inland in the Columbia, Snake and Yakima Rivers (Wydoski and Whitney 2003). They occur below Chief Joseph Dam in the Columbia River system and below Hells Canyon Dam in the Snake River (Moser and Close 2003). Historically, Pacific lamprey were found as far upstream as Kettle Falls on the Columbia River and Spokane Falls on the Spokane River, but passage was blocked with the completion of Grand Coulee Dam in 1941, and in 1955,

Chief Joseph Dam blocked an additional 52 miles of the Columbia (Wydoski and Whitney 2003). Pacific lamprey are also located in streams along the southern, western and northern boundaries of the Olympic Peninsula. Evidence of dwarf parasitic landlocked populations in Oregon and California exists, but no documentation of such occurs within Washington (Wydoski and Whitney 2003). A figure representing the freshwater distribution of Pacific lamprey in Washington may be found in Appendix F.

4-10.4 Habitat Use

ADULT

Pacific lampreys are anadromous fish that utilize both freshwater and marine environments during their complex life history. They are the largest of the native lamprey, and adults may reach a length of 76 centimeters and a weight of 450 grams (Wydoski and Whitney 2003). Young Pacific lamprey migrate from their natal rivers to the Pacific Ocean, where they remain as adults from 20 to 40 months before returning to freshwater for spawning. Pacific lamprey have been found from 9 to 100 kilometers offshore in waters as deep as 800 meters, although they are more commonly located in water depths of 70 to 250 meters (Wydoski and Whitney 2003). Adult Pacific lamprey are parasitic toward other fish (for example, salmonids, rockfish, flounders, lingcod, sablefish, cod and halibut) and some marine mammals (such as whales), and utilize suckerlike mouthparts to remove body fluids from host organisms. Landlocked Pacific lamprey populations spend their entire lives in fresh water, but still exhibit a parasitic adult phase (Wydoski and Whitney 2003).

SPAWNING

Adult Pacific lamprey begin the journey to freshwater streams and rivers as early as one year before they intend to spawn, overwinter in deep pools, and then spawn in the spring. Some individuals may migrate hundreds of miles upstream to spawning habitats, and may pass barriers such as waterfalls by slowly ascending them with their suckerlike mouths (Wydoski and Whitney 2003). Pacific lamprey appear to be nocturnal and appear to move primarily at night (Moser and Close 2003). Upon returning to freshwater, Pacific lamprey stop parasitic feeding and rely exclusively on stored carbohydrates, proteins and lipids until they spawn. Spawning occurs from February through July, with spawning in coastal streams occurring earlier than those more inland (Moser and Close 2003). Both male and female Pacific lamprey help in the construction of the nest on the gravel stream bed; nests measure 20 to 30 centimeters in diameter and 2.5 to 8 centimeters deep (Wydoski and Whitney 2003). Nests are generally located in riffles or the tails of pools in moderate- to high-flow streams at depths less than one meter (Moser and Close 2003). Pacific lamprey deposit eggs and milt in the gravel nest; one female can produce between 34,000 and 238,400 eggs, depending on her size (Wydoski and Whitney 2003).

Although Pacific lampreys typically die within days after spawning, tag-recapture observations cited by Wydoski and Whitney (2003) suggest that some individuals may spawn more than once in their lifetime. Historically, lamprey returning to spawn in freshwater streams and rivers were often captured by Pacific Northwest American tribes, who considered them important for food, as well as for ceremonial and medicinal

purposes (Wydoski and Whitney 2003). They are also considered ecologically important to Pacific Northwest ecosystems, returning marine-derived nutrients to the freshwater environment and providing an important forage base for marine mammals, birds and fishes (Lower Columbia Fish Recovery Board 2004).

INCUBATION / EMERGENCE / LARVAE

Pacific lamprey spawn at water temperatures between 10 and 15° Celsius; eggs are incubated in 15° Celsius water and hatch in 2 to 3 weeks (Wydoski and Whitney 2003). After hatching at about 1 centimeter length, larvae (“ammocoetes”) burrow into silty substrates and remain within slow-moving reaches of streams, where they feed by filtering microscopic plants and animals out of the water (Moser and Close 2003). The ammocoete stage is characterized by undeveloped eyes, reduced fins and the absence of tooth-like plates at its oral opening (Meeuwig et al. 2003). The Pacific lamprey remains as an ammocoete in freshwater habitats for 4 to 7 years and can reach a size of up to 17 centimeters before metamorphosing into its parasitic adult phase (Moser and Close 2003). Adulthood for the Pacific lamprey follows a metamorphosis in which the larvae develop eyes, an oral disc and “teeth” (supra-oral lamina) (Wydoski and Whitney 2003). Metamorphosis occurs from July until November, and the newly metamorphosed lamprey may either begin a migration toward sea immediately or remain in fresh water for up to 10 months before beginning its journey (Wydoski and Whitney 2003). Just as anadromous Pacific lamprey move from their natal streams to the marine environment for their adult parasitic phase, landlocked Pacific lamprey similarly exhibit movements from a stream to a larger body of freshwater (Meeuwig et al. 2003).

4-10.5 Population Trends

Similarly to the river lamprey (*Lampetra ayresi*), the population status of Pacific lamprey is difficult to assess because 1) most freshwater observations are based on juveniles that are difficult to differentiate from other lamprey species, 2) data are often incidental to salmon monitoring programs, and 3) there are few historical datasets on lamprey populations in existence (Kostow 2002). Fish ladder observations, although focused on salmon, have suggested that the numbers of adult Pacific lamprey returning to spawn have declined severely as recently as the 1980s. Counts from Bonneville Dam in 1968 reported 380,000 adults, but more recently, the annual counts are nearer 40,000 adults; counts from other dams show similar declines (Wydoski and Whitney 2003). Anecdotal historical observations and information from Northwest tribes suggest a similar declining abundance pattern (Kostow 2002). However, Pacific lamprey populations occur in clusters (Lower Columbia Fish Recovery Board 2004), and lamprey abundance can fluctuate wildly from year to year and between locations. Because the dynamics of lamprey populations and the distribution of lamprey production remain rather enigmatic, it is difficult to interpret the few quantitative data that have been collected (Kostow 2002).

4-10.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

General causes of Pacific lamprey declines throughout their range include flow regulation (Wallace and Ball 1978; Beamish and Northcote 1989), channelization (Kirchhofer 1995), poor water quality (Myllynen et al. 1997), and chemical treatments (Schuldt and Goold 1980). Flow regulation, which is common throughout most of the United States, impacts adults by impeding passage at dams, while larvae are affected by the dewatering of rearing habitat. River channelization negatively impacts larval lamprey habitat by increasing velocity, thereby reducing depositional areas. Furthermore, larvae are more susceptible to toxicological effects from contaminants because of their sedentary life in the benthos, as demonstrated by chemical treatments used in streams of the Great Lakes to control nonnative sea lamprey (*Petromyzon marinus*) and resulting declines in native lamprey populations (Close et al. 2002).

Modification of river habitats used by spawning adult and larval stages is thought to represent the biggest threat to Pacific lamprey (as it does to other lamprey species). Dams, culverts, tidegates, weirs and water-diversion structures prevent adult Pacific lamprey from accessing spawning habitats and may cause high mortality of outmigrating ammocoete larvae (Kostow 2002). River flows, which stimulate migratory behavior of outmigrating larvae, have been altered substantially by reservoir and dam construction, and may be detrimental to Pacific lamprey populations by delaying outmigration behavior (Kostow 2002). In addition, rapid water drawdown in reservoirs may strand lampreys in their burrows (Kostow 2002). Most industrial, urban and agricultural development is concentrated in low-gradient, lower river flood plains that are favored by Pacific lampreys.

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Commercial harvest of Pacific lamprey has occurred historically in some locations, where it was exported to Europe or used to formulate feed for salmon hatcheries, livestock and poultry; commercial harvest has been limited in the Willamette River, Oregon, since 2000 because of concerns about declining populations. The Pacific lamprey is also used for food, ceremonial and medicinal purposes by Native Americans (Lower Columbia Fish Recovery Board 2004). White sturgeon fishermen on the Columbia use adult Pacific lamprey as bait, and ammocoetes have been used by trout fisherman as bait in other locations (Wydoski and Whitney 2003). A biological supply company regularly collected Pacific lamprey at Willamette Falls, Oregon, as teaching specimens (Wydoski and Whitney 2003). Sustainable harvest rates are unclear, because there is often very little information about lamprey population dynamics or productivity (Kostow 2002).

DISEASE OR PREDATION

There are two periods when larvae are subjected to predation: during emergence from nests and during scouring events that dislodge the larvae from their burrows (Close et al. 2002). Adult lamprey comprise a high value food resource for a wide variety of consumers because they have high caloric value per unit weight, travel in schools, and are rich in fats (Close et al. 2002). Pacific lamprey is found in the diets of several fish species (Poe et al. 1991), birds (Merrell 1959) and pinnipeds (Roffe and Mate 1984), with Close et al. (2002) suggesting that some density dependent predators may pose a barrier to recovery for Pacific lamprey.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

The current lack of data related to populations, distribution, harvest and the ability of the Pacific lamprey's to survive upstream-passage facilities make it likely that existing regulatory mechanisms are inadequate to protect this species.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Much like salmon, there are many reasons for the observed reductions in range and abundance of Pacific lampreys, and no single threat can be pinpointed as the primary reason for their apparent decline.

Larval lamprey burrow in river-bottom sediment during their entire larval life span, and may be affected by toxic pollutants sequestered in areas with contaminated sediment. Pacific lamprey may also be taken by dredging operations (Kostow 2002). This species is often concentrated in remarkably high densities in some stream areas, and as such, is particularly vulnerable to chemical spills or other catastrophic events (Kostow 2002).

Some have also suggested that declines in salmonid populations have resulted in declines in Pacific lamprey populations because lampreys rely heavily on salmonids for food (Wydoski and Whitney 2003). Declines in adult populations of Pacific salmon (*Oncorhynchus* spp.), Pacific hake (*Merluccius productus*), and walleye pollock (*Theragra chalcogramma*), which serve as host species to the parasitic adult stage of Pacific lampreys, may affect populations of Pacific lamprey (50 CFR 17, 2004).

4-10.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Pacific lamprey are most likely to be affected by activities authorized by Washington DNR on state-owned aquatic lands in riverine and nearshore marine habitats of the interior coastal rivers of Puget Sound, the outer coast and the Columbia River and its tributaries. Areas of concern include dams and other diversion/impoundment structures blocking adult migration, entraining outmigrating larvae, and altering stream flow and temperature; outfalls or other activities that may contribute toxic contaminants to riverine sediment used by larvae; and sediment disturbance or removal associated with mining and dredging activities.

4-10.8 Species Coverage Recommendation and Justification

It is recommended that Pacific lamprey be listed as an **Evaluation Species** because: 1) The species is considered a federal Species of Concern, but during a recent evaluation of this species for listing status, US Fish and Wildlife was unable to describe a listable entity for the Pacific lamprey, therefore making it “ineligible for listing at this time” (50 CFR 17, 2004); 2) Washington DNR authorized activities have a “medium” potential to affect Pacific lamprey; and 3) Information is currently insufficient to adequately assess potential effects and develop conservation measures for the Pacific lamprey.

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4-11 Pink Salmon

4-11.1 Species Name

Oncorhynchus gorbuscha

Common Name(s): Pink salmon, humpback salmon, humpies

Initial coverage recommendation: Evaluation

4-11.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not listed

WASHINGTON FISH AND WILDLIFE STATUS

Not listed

NATURAL HERITAGE PROGRAM GLOBAL RANK

G5

NATURAL HERITAGE PROGRAM STATE RANK

S2

4-11.3 Range

Pink salmon are the most abundant species of salmon and are found throughout the north Pacific, including northern Asia. The North American range is from the Sacramento River in northern California, north to the Bering Strait, and east to the MacKenzie River in northern British Columbia, though spawning is rare south of the Columbia River (Wydoski and Whitney 2003). They are most common from central Alaska south to the Fraser River in British Columbia (Quinn 2005).

Thirteen stocks of pink salmon have been identified in Washington, with actively spawning populations occurring in the Nooksack, Skagit, Stillaguamish, Snohomish, Skykomish, Snoqualmie, Puyallup, Nisqually, Hamma Hamma, Duckabush, Dosewallops, Dungeness and Elwha Rivers (Wydoski and Whitney 2003). Pink salmon

have been reported in other systems (e.g., Bogachiel River, Lake Washington), but these are considered strays, not spawning populations (Wydoski and Whitney 2003). A figure representing the freshwater distribution of pink salmon in Washington may be found in Appendix F.

4-11.4 Habitat Use

ADULT

Pink salmon, the smallest of the Pacific salmon, mature and spawn on a two-year cycle. In Washington, pink salmon spawn only in odd years except for the Snohomish River, which has both odd and even-year spawners (Wydoski and Whitney 2003). This species is an opportunistic, generalized feeder, foraging on a variety of forage fish (herring, sand lance), crustaceans (crab larvae, copepods, amphipods, euphausiids), ichthyoplankton and zooplankton (Heard 1991). Adults range in length from 0.3 to 0.75 meters with weights averaging almost 2 kilograms (Wydoski and Whitney 2003) and spend a little over a year in the open ocean before returning to spawn.

SPAWNING/INCUBATION/EMERGENCE

Spawning migrations occur between mid-June and late October, although in Washington they are most common during August and September (Hard et al. 1996; Wydoski and Whitney 2003). Arrival time of pink salmon can vary within the same river system, causing an early and late run (Hard et al. 1996).

It is rare for Pink salmon to make extended spawning runs like other species of salmon, and spawning generally occurs near river mouths or a short distance upstream in rivers with fast-flowing current (Wydoski and Whitney 2003). Unlike many other salmonids, pink salmon will spawn in rivers with substantial amounts of silt from glacial runoff such as the Nisqually and Nooksack (Hard et al. 1996). Some researchers have linked the timing of this species spawning runs to water temperature and tidal/current conditions in the nearshore bays and estuaries of the fishes natal rivers (Heard 1991). Spawners may remain in local bays for up to a month before migrating into the river, it is believed that this delay allows for full gonadal development (Heard 1991). Although intertidal spawning is known to occur, it is not common in Washington (Hard et al. 1996).

Pink salmon spawning behavior is similar to that of other salmonids, with females generally digging redds in riffles with small- to medium-sized gravel, though they may also use the tail-ends of pools (Wydoski and Whitney 2003). The incubation period for this species is approximately five months, with emergence taking place between late January and April and peaking during March and April (Hard et al. 1996). As egg development is highly dependent upon water temperature, the time periods for incubation and emergence timing vary from year to year (Wydoski and Whitney 2003). After the eggs hatch, the alevins may remain in the interstitial spaces of the gravel for several months (Heard 1991), with the fry emerging from the gravel at about 30 millimeters in length and fully prepared for migration to saltwater (Quinn 2005).

REARING/OUT-MIGRATION

Pink salmon migrate downstream almost immediately after emergence and if the distance to saltwater is short, the migration may occur in one night (Heard 1991). The species spends very little time in estuarine environments, moving quickly to marine nearshore habitats where they grow rapidly, feeding on small crustaceans, such as euphausiids, amphipods and cladocerans (Hard et al. 1996). Prey may be benthic or pelagic in nature, though foraging usually occurs in the water column in nearshore areas, along beaches or shorelines with complexity (Heard 1991). Juveniles form schools in estuaries for several months during the summer before moving offshore by late summer or early fall (Hart et al. 1996; Wydoski and Whitney 2003). Some Puget Sound populations spend their entire marine life in marine nearshore habitats (Hard et al. 1996).

4-11.5 Population Trends

According to Hart et al. (1996), pink salmon populations are relatively healthy in the state of Washington, with the exception of rivers along the Strait of Juan de Fuca. The Elwha River population is thought to be extinct and the Dungeness River stocks are considered depressed as a result of heavy flooding in 1979 and 1980 (Hart et al. 1996). Both anthropogenic and natural disturbances have profound impacts on this species due to their strict two-year life cycle (Heard 1991).

4-11.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Because pink salmon spawn and incubate in rivers and streams, they are particularly susceptible to human-induced changes in water quality and/or habitat degradation. Spawning habitat is particularly subject to the negative impacts from land-use activities such as logging, agriculture, grazing practices, and urban/suburban development. Common problems include modification of flow regimes, non-point source pollution and physical habitat destruction. Additional impacts to pink salmon populations may result from habitat loss as a result of physical barriers to migration (i.e. blocked culverts, dams, water-diversion structures); high temperatures and low flows; and natural events, such as landslides or flood-induced changes.

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Pink salmon account for over 50 percent of the commercial salmon harvest on the west coast (Wydoski and Whitney 2003) and while there is some indication that escapement has declined in British Columbia, over-utilization has not been identified as a threat to Washington populations (Hard et al. 1996).

DISEASE OR PREDATION

Atlantic salmon aquaculture may cause extremely high sea lice (*Lepeophtheirus salmonis*) infestation rates in pink salmon (Morton et al. 2004). Because net pen farms may offer suitable overwintering habitat for sea lice, and pink salmon are small during their nearshore life stage, sea lice infection may result in the high mortality of pink salmon (Morton et al. 2004). Disease from sea lice infection includes skin erosion and hemorrhaging that can result in lethal bacterial infections, fungal infections and osmoregulatory failure (Wootton et al. 1982). Pink salmon are common prey items for marine mammals in the Gulf of Alaska and are also eaten by Pacific halibut, though consumption rates don't appear to have a major impact on the population (Heard 1991).

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Few regulatory mechanisms exist for pink salmon. Where the species overlaps with Chinook and summer chum salmon, such as in some of the Puget Sound rivers and in Hood Canal, it is protected by regulatory mechanisms related to those species status as Threatened or Endangered under ESA.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Habitat destruction is the most pressing concern for all salmon species. Their unique and diverse habitat requirements make them especially susceptible to disturbance. Pink salmon make heavy use of nearshore marine areas along Puget Sound and Hood Canal, and alteration of this zone may impede their rearing and migration.

1-5.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Pink salmon may be affected by a variety of activities authorized by Washington DNR on state-owned rivers, estuaries and nearshore marine areas. Like other salmonids, they experience high rates of mortality during incubation, and disturbances, such as increased siltation, high or low water velocities and volumes, or increased temperatures may further impede successful emergence. Nearshore areas are thought to be of high importance for pink salmon and activities that result in the removal of eelgrass or decreased benthic production, such as the construction and operation of over-water structures or shoreline armoring modifications may reduce their ability to forage and/or migrate. Outfalls may cause localized reductions in water and sediment quality, resulting in increased turbidity, reduced foraging efficiency, diminished habitat quality and increased potential for the bioaccumulation of pollutants. The construction of roads and bridges may cause increased sedimentation during construction, and may increase temperature and pollutant loads from stormwater runoff during operation. Aquaculture operations may result in disease transmission, decreased dissolved oxygen levels and genetic dilution. They may also impact salmon through the increases in nitrogenous waste and the introduction of chemicals such as antifoulants, pesticides and antibiotics.

4-11.8 Species Coverage Recommendation and Justification

Pink salmon should be considered a **Evaluation Species** for the following reasons: 1) While pink salmon are not currently listed by either the state or federal government, they are considered Imperiled within the state of Washington by the Natural Heritage Program; 2) Washington DNR authorized activities have a “medium” potential to affect the species; and 3) Sufficient information exists to assess impacts and to develop conservation measures.

4-11.9 References

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4-12 River Lamprey

4-12.1 Species Name

Lampetra ayresi

Common Name: River lamprey

Initial coverage recommendation: Covered

4-12.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Species of Concern

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

State Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

G4

NATURAL HERITAGE PROGRAM STATE RANK

S2

4-12.3 Range

The river lamprey inhabits coastal streams from northern California to northern British Columbia and southeastern Alaska (Wydoski and Whitney 2003). However, there have been few definitive collections or sightings of lamprey within its entire range in recent years (Meeuwig et al. 2003). The Oregon Department of Fish and Wildlife is not even certain if river lampreys are still present in Oregon (Kostow 2002). Part of this confusion may be that, except for the last 6 months to 1 year of life, the western brook lamprey and the river lamprey are indistinguishable from each other (Kostow 2002).

In Washington, there are no detailed distribution records for river lamprey, although the species probably occurs in most major rivers (Wydoski and Whitney 2003) and is thought to inhabit portions of the Columbia River, some rivers of the Western coast, and Puget

Sound. Reports of river lamprey exist for the Lake Washington drainage, Lake Sammamish and within Hood Canal near Seabeck (Wydoski and Whitney 2003). River lamprey have also been collected more recently in Skagit Bay (Meeuwig et al 2003). A figure representing the freshwater distribution of river lamprey in Washington may be found in Appendix F.

4-12.4 Habitat Use

ADULT

River lamprey are anadromous fish that utilize freshwater and marine environments throughout their life history. Young river lampreys from British Columbia rivers migrate to the sea between the months of April and June at an average size of almost 11 centimeters. Adults then spend 4 to 5 months feeding at sea before returning in the fall for spawning the following spring (Wydoski and Whitney 2003). While at sea, adult river lamprey use cusped teeth in their sucker-like mouths to remove large chunks of flesh from host fish and because of this behavior, some consider the river lamprey to be more predatory than parasitic (Kostow 2002). Diet studies have shown that adult river lamprey in marine habitats feed on herring, smelt and salmonids; in laboratory studies, they have been observed feeding on shiner perch, English sole and even other river lamprey (Wydoski and Whitney 2003). River lamprey are found near the mouth of major rivers at depths of less than 49 meters (160 feet), although off the coast of British Columbia, adults are found in the surface waters at depths of 26 to 33 meters (85 to 108) feet between May and September (Wydoski and Whitney 2003). It is thought that river lamprey may have a preference for water with reduced salinity because they tend to be distributed in surface waters in the vicinity of major rivers, where salinities ranged between 26 to 30 practical salinity units. Adult river lamprey in the Pacific Ocean off British Columbia ranged in size from 14 to 25 centimeters. River lamprey begin their return to freshwater in September after several months of feeding at sea.

SPAWNING

Adult river lamprey begin the journey to freshwater in the fall, overwinter in freshwater streams and rivers, and then spawn the following spring (Wydoski and Whitney 2003). In Washington State, spawning typically occurs from April to June, with the peak occurring in May, when water temperatures are around 12° Celsius. In a laboratory study, river lamprey were observed to construct nests in gravel of roughly 15 centimeters in diameter (Wydoski and Whitney 2003). They then deposit eggs and milt in the gravel nest; females produce 11,000 to 37,000 eggs during a spawning event. All river lamprey die soon after spawning (Wydoski and Whitney 2003).

INCUBATION / EMERGENCE / LARVAE

Little published information exists on the early life history of river lamprey, including the temperature and flow requirements of their eggs or the specific freshwater habitat requirements of their larvae (Kostow 2002). After hatching, river lamprey ammocoetes remain in the silt and sediment of coldwater streams and rivers, where they feed on microscopic organisms and algae (Wydoski and Whitney 2003). Ammocoetes are

thought to remain in freshwater river habitats for up to several years, where they favor low-gradient reaches in lower river flood plains. As the ammocoetes migrate downriver to the Pacific Ocean, they metamorphose into young adults, developing eyes and an oral disc.

4-12.5 Population Trends

The population status of the river lamprey is difficult to assess because 1) most freshwater observations are based on juveniles that are difficult to differentiate from other lamprey species, 2) data are often incidental to salmon monitoring programs, and 3) there are few historical datasets on lamprey populations in existence. Abundance in the Strait of Georgia, British Columbia, was estimated at 189 river lamprey per square kilometer (Wydoski and Whitney 2003). Because adult river lamprey tend to not move far from the estuaries of their natal rivers, it is thought that this species is geographically discrete, with individual stocks genetically unique (Kostow 2002).

4-11.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

River lamprey are likely susceptible to threats similar to those described for the Pacific lamprey. Modification of river habitats used by spawning adult and larval stages of river lamprey is thought to represent the biggest threat to this species. Dams, culverts, tidegates, weirs and water-diversion structures prevent adult river lamprey from accessing spawning habitats and may cause high mortality of outmigrating ammocoete larvae (Kostow 2002). River flows, which stimulate migratory behavior of outmigrating larvae, have been altered substantially by reservoir and dam construction, and may be detrimental to river lamprey populations by delaying outmigration behavior (Kostow 2002). In addition, rapid water drawdown in reservoirs may strand lampreys in their burrows (Kostow 2002). Most industrial, urban, and agricultural development is concentrated in low-gradient, lower river flood plains that are favored by lampreys.

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

River lamprey are of relatively small size (returning adults are between 20 to 30 centimeters in length) (Wydoski and Whitney 2003) and are not used extensively for commercial, recreational, scientific or educational purposes.

DISEASE OR PREDATION

Disease and predation are not currently thought to represent major threats to the continued survival of river lamprey.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

The current lack of data related to populations, distribution, harvest and the ability of the river lamprey to survive upstream-passage facilities make it likely that existing regulatory mechanisms are inadequate to protect this species. Other Factors Affecting Continued Existence

Larval river lampreys burrow in river-bottom sediment during their entire larval life span, and may be affected (through ingestion and external exposure) by toxic pollutants sequestered in areas with contaminated sediment. River lamprey were often found in dredged sediment taken from the lower Fraser River, and have relatively low survival rates (3 to 26 percent) after passing through the dredge (Kostow 2002). River lamprey are often concentrated in remarkably high densities in some stream areas, and as such, are particularly vulnerable to chemical spills or other catastrophic events.

4-12.7 Assessment of Potential Effects from Washington DNR Authorized Activities

River lamprey are most likely to be affected by activities authorized by Washington DNR on state-owned aquatic lands in riverine and nearshore marine habitats of interior and coastal rivers of Puget Sound, the outer coast and the Columbia River and its tributaries. Areas of concern include dams and other diversion/impoundment structures blocking adult migration, entraining outmigrating larvae, and altering stream flow and temperature; outfalls or other activities that may contribute toxic contaminants to riverine sediment used by larvae; and sediment disturbance or removal associated with mining and dredging activities.

4-12.8 Species Coverage Recommendation and Justification

It is recommended that river lamprey be listed as an **Evaluation Species** because: 1) The species is a federal species of concern and a state Candidate Species; 2) Washington DNR activities have a “medium” potential to affect river lamprey; and 3) Information is currently insufficient to adequately assess potential effects and develop conservation measures for the river lamprey.

4-12.9 References

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4-13 White Sturgeon

4-13.1 Species Name

Acipenser transmontanus

Common Name: White sturgeon

Initial coverage recommendation: Covered

4-13.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

No white sturgeon population found in Washington State is listed under the Endangered Species Act, although the Kootenai River white sturgeon populations in Idaho, Montana and British Columbia were listed as Endangered in 1994 (US Fish and Wildlife 2005).

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Not listed

NATURAL HERITAGE PROGRAM GLOBAL RANK

G4

NATURAL HERITAGE PROGRAM STATE RANK

S3B, S4N

4-13.3 Range

White sturgeon are found in coastal marine waters from Ensenada, Mexico, northward to Cook Inlet in northwestern Alaska (Emmett et al. 1991). Significant, reproducing populations of the species appear to be limited to the Sacramento, Columbia and Fraser Rivers (Wydoski and Whitney 2003). The Kootenai River white sturgeon in Idaho, Montana and British Columbia was genetically isolated from the lower Columbia River drainage by a natural barrier present since the last ice age and is the only population considered Endangered (Wydoski and Whitney 2003).

In Washington, white sturgeon are found in all nearshore marine waters in interior and coastal waters, and are considered common to abundant in Willapa Bay, Grays Harbor and the lower Columbia River, and rare in Puget Sound and Hood Canal (Emmett et al. 1991). The species can also be found in several large freshwater rivers, although the only reproductive populations in the state are found in the Columbia River (Wydoski and Whitney 2003). Dams along the Columbia River have changed the white sturgeon's historical range, creating a number of landlocked populations that are functionally restricted to these impoundments. Columbia River populations are divided into those downstream of Bonneville Dam with access to the ocean, and those present in the reservoirs and stretches of river above Bonneville Dam. White sturgeon have also been observed concentrating in some other freshwater tributaries (e.g., Salmon Creek in Discovery Bay) of Puget Sound / Strait of Juan de Fuca (Johnson, Personal communication: March 16, 2005). A figure representing the freshwater distribution of white sturgeon in Washington may be found in Appendix F.

4-13.4 Habitat Use

ADULT

The white sturgeon is a long-lived species, with a life span that may exceed 100 years (Emmett et al. 1991) and is the largest fish found in freshwater in North America (Wydoski and Whitney 2003). This species is anadromous, although it is also capable of completing its entire life cycle in fresh water. White sturgeons are slow to mature, with 95 percent of females in the lower Columbia River becoming sexually mature between 16 and 35 years of age when they are approximately 2 meters in length; males in some areas mature as young as 9 years of age and at a smaller size than females (approximately 1.3 meters) (Wydoski and Whitney 2003).

In freshwater systems, adult white sturgeon occur in large, low-gradient rivers and associated impoundments, and are generally found in the larger, deeper pools and eddies of main river channels where water velocity is lower. In the unimpeded reach of the Columbia River below Bonneville Dam, sturgeon appear to migrate upstream into tidal freshwater habitats during the fall and downstream into marine-influenced habitats in the late winter and spring (Wydoski and Whitney 2003). In marine systems, adult and subadult white sturgeon use a variety of unconsolidated estuarine and nearshore marine habitats, and may move onto intertidal flats to feed at high tide (Emmett et al. 1991). Adult and subadult white sturgeon may also spend time in the open ocean of the Pacific, and some individuals move among coastal river systems and estuaries.

White sturgeon are generally demersal (associated with the bottom), and use barbels on their snout to locate prey in turbid bottoms. Adults feed on a variety of organisms, including fish (smelt, northern anchovy, salmon and herring), crustaceans (shrimp, amphipods, isopods and crab), worms and mollusks (clams, snails and mussels) (Emmett et al. 1991; Wydoski and Whitney 2003). Older juveniles and subadults in unimpounded river systems (e.g., Fraser and Columbia Rivers) are often found in estuarine habitats, where they consume a variety of benthic and epibenthic invertebrates, including tube-dwelling amphipods (*Corophium* sp.), bivalves, shrimp and chironomids (Emmett 1995; Wydoski and Whitney 2003).

SPAWNING

Spawning by adult white sturgeon typically occurs in early spring to early summer (Emmett et al. 1991; Wydoski and Whitney 2003). Adults generally spawn in large river channels with swift currents (0.7 to 2.8 meters per second in the Columbia River) and a substrate composed of cobble or boulders. These habitats are often limited to areas below rapids or dams. White sturgeon are broadcast spawners with external fertilization and adults may spawn multiple times within their life, with 3 to 11 years between spawning events (Emmett et al. 1991; Wydoski and Whitney 2003). Fecundity of white sturgeon is high with mature females producing between 100,000 to 300,000 eggs and larger individuals producing over a million eggs.

INCUBATION, EMERGENCE AND LARVAE

The sticky fertilized eggs of white sturgeon settle to the river bottom, where they attach to cobble, incubate and hatch in 4 days to 2 weeks, depending on temperature (Emmett et al. 1991). Incubation occurs at temperatures ranging between 10° Celsius to 18° Celsius egg mortality occurs at temperatures exceeding 20° Celsius (Wydoski and Whitney 2003).

Larvae range in size between 8 to 19 millimeters in total length (Emmett et al. 1991). Larvae are found throughout the water column, but become oriented to the bottom within 5 to 6 days after developing pectoral fins. Larval survival is likely dependent on sustained, high riverine flows and low temperatures (Emmett et al. 1991). Larval white sturgeon deplete their yolk sacs approximately 12 days after hatching, and metamorphose to juveniles when about 20 millimeters long.

EARLY JUVENILES

Juveniles less than one year old are found only in freshwater habitats, where they feed on algae and small invertebrates (Emmett et al. 1991). In the Columbia River, young-of-the-year white sturgeon were collected over unconsolidated sediments in water 13 to 27 meters deep with an average velocity of 0.4 meters per second (Wydoski and Whitney 2003). Subyearlings were also common during the summer over unconsolidated substrates in shallow freshwater areas of the San Joaquin Delta (Emmett et al. 1991).

Habitat use by older juveniles (subadults) is similar to that of adult white sturgeon.

4-13.5 Population Trends

White sturgeon populations in the Columbia River were nearly decimated in the 1890s as a result of unregulated exploitation, obstruction of migration by dams, altered streamflows, altered temperature regimes and reduced spawning habitat (DeVore et al. 1999; Wydoski and Whitney 2003). In the Lower Columbia River, populations rebounded after maximum size regulations designed to protect sexually mature sturgeon were enacted in 1950 (DeVore et al. 1999). Since that time, management restrictions on harvested fish size, daily quotas and yearly quotas have allowed the Lower Columbia population to recover and harvest to continue at a sustainable level. Currently, the white sturgeon population in the Lower Columbia River downstream of Bonneville Dam is the

most productive in the species' range (DeVore et al. 1999). More conservative management strategies have recently been recommended for this population because of evidence of reduced recruitment into Lower Columbia fisheries and increased emigration from the Lower Columbia (DeVore et al. 1999).

Populations in impounded sections of the Columbia Basin have been depressed since construction of mainstem dams, which limit seasonal streamflows and the movement of individuals, as well as adversely affect spawning and recruitment (Parsley and Beckman 1994; Wydoski and Whitney 2003). Of the 11 mainstem Columbia River populations isolated between dams, white sturgeon are considered relatively abundant in only 3 locations in Washington (above Bonneville, the Dalles and Grand Coulee Dams) (Miller et al. 2005). White sturgeon are considered relatively abundant in only 2 of the 12 impoundments located in the Snake River (in Washington State above the Lower Granite Dam) (Miller et al. 2005). The Kootenai River population is unstable and declining as a result of the loss of spawning habitat from altered river flows (Miller et al. 2005; US Fish and Wildlife 2005).

4-13.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Dam construction and channel modifications are considered major causes of the sturgeon decline in the Columbia River basin and many other locations (Beamesderfer and Farr 1997). The loss of spawning grounds and suitable sites for incubation and rearing of early life stages by creation of reservoirs has appeared most critical. In addition to isolating populations (Wydoski and Whitney 2003), dams also alter seasonal streamflows and water temperatures affecting the composition and extent of spawning habitat, as well as spawning behavior (Parsley and Beckman 1994; Wydoski and Whitney 2003; Miller et al. 2005).

Recruitment failure is a major feature of many of the subpopulations segmented by dams (Parsley et al. 2002; Upper Columbia White Sturgeon Recovery Initiative 2002). The species continues to persist in most of its range largely because of individual longevity (up to 100 years), but the population status is not satisfactory enough to sustain a major fishery except in the lower river downstream of Bonneville Dam, the lowermost dam in the river (Parsley et al. 2002).

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Overharvest by commercial and recreational fisheries has been the major contributor to the collapse of some stocks of sturgeon (Dumont 1995; Echols 1995; Rosenthal et al. 1999). White sturgeon are particularly susceptible to overharvest because of their slow growth, late onset of maturity and episodic spawning behavior (Wydoski and Whitney 2003). Refinement of management strategies is still needed in some areas (DeVore et al. 1999).

DISEASE OR PREDATION

Disease and predation are not currently thought to represent major threats to the continued survival of white sturgeon.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Regulatory mechanisms (e.g., harvest regulations) are generally considered adequate for protection of white sturgeon populations, although more conservative management strategies have recently been recommended for the population in the Lower Columbia River because of evidence of reduced fishery recruitment and increased emigration from the system (DeVore et al. 1999).

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

White sturgeon are a long-lived species and may also be at risk due to bioaccumulation and concentration of contaminants (Emmett et al. 1991). Additional factors affecting their existence include impacts to eggs and larvae from climate induced changes in water temperature and hydrology; decreases in dissolved oxygen resulting from anthropogenic eutrophication (Klyashtorin 1976; Secor and Gunderson 1998).

4-13.7 Assessment of Potential Effects from Washington DNR Authorized Activities

White sturgeon in the offshore environment are not likely to be affected by most activities authorized by Washington DNR on state-owned aquatic lands. Areas of concern include activities authorized within nearshore and estuarine habitats of Grays Harbor, Willapa Bay, Puget Sound, Hood Canal and the Columbia River, and in freshwater habitats of the upper Columbia River, where isolated white sturgeon populations still exist. Discharges from outfalls and runoff from impervious surfaces (roads, docks) may contribute toxic contaminants to aquatic habitats used by sturgeon. Activities that alter feeding, spawning and rearing habitats, such as shellfish aquaculture in tidal flats and sediment disturbance associated with mining and dredging activities, may adversely impact white sturgeon. White sturgeon may be affected by invasive-species control activities that affect prey species (e.g., benthic and epibenthic invertebrates). Transportation-related activities involving construction of highways, roads and railroad structures, including pile-driving may affect sturgeon habitat.

4-13.8 Species Coverage Recommendation and Justification

It is recommended that white sturgeon be listed as an **Evaluation Species** because: 1) No Washington State white sturgeon populations have federal or state listing status; 2) Washington DNR activities have a “medium” potential to affect white sturgeon; and 3) Sufficient information currently exists to adequately assess potential effects and develop conservation measures, as appropriate.

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4-14 Leopard Dace

4-14.1 Species Name

Rhinichthys falcatus

Common name: Leopard dace

Leopard dace are members of the Genus *Rhinichthys* and are very similar morphometrically to Umatilla dace *Rhinichthys umatilla*. Leopard and Umatilla dace were previously considered to be sub-species of the taxonomically similar speckled dace (Wydoski and Whitney 2003) and have only recently been recognized as separate species by the American Fisheries Society (Nelson et al. 2004). Leopard dace exhibit only small morphological differences from Umatilla dace such as the presence of fleshy stays on the rays of the pelvic fins, the presence of dark spots along the lateral line, a relatively narrow caudal peduncle and, larger and fewer lateral line scales (Hass 2001, Wydoski and Whitney 2003). Leopard dace also exhibit different habitat usage than Umatilla dace, opting for greater water velocities (Haas 2001).

Initial coverage recommendation: Covered

4-14.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not listed

WASHINGTON FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

G4

NATURAL HERITAGE PROGRAM STATE RANK

S2, S3

4-14.3 Range

Leopard dace occur in sporadic and disconnected regions of British Columbia, Idaho, Oregon and Washington. Although information regarding this species is generally lacking, it is believed that they are limited to the Fraser and Columbia River systems east of the Cascade Mountains (Scott and Crossman 1973). Within Washington, leopard dace currently inhabit the lower, mid and upper reaches of the Columbia, Snake, Yakima and Similkameen Rivers although they are exceptionally rare below Prosser, Sunnyside and Roza Dams in the Yakima River (Wydoski and Whitney 2003) (Appendix F). Leopard dace have been found to be allopatric and sympatric with Umatilla and speckled dace.

4-14.4 Habitat Use

ADULTS

Leopard dace are a demersal fish, and utilize habitat on or near the bottom of streams and small to mid-sized rivers with stream velocities less than 0.5 meters per second. The species prefers substrates comprised of stones covered by fine sediments, with summer water temperatures ranging between 15 and 18° Celsius, and is rarely found at depths greater than 1 meter (Peden 1991; Wydoski and Whitney 2003). Individuals may live up to 5 years in the wild, attaining lengths of 6 to 15 centimeters (Wydoski and Whitney 2003; Froese and Pauly 2004). Although juveniles feed primarily on aquatic insects, adult leopard dace consume terrestrial insects (Wydoski and Whitney 2003).

SPAWNING

Very little is known about leopard dace spawning habitat or behavior, although it is believed to be similar that of longnose and speckled dace. These dace primarily spawn in riffles with females depositing adhesive eggs over unprepared gravel or small stones in the presence of multiple males (Scott and Crossman 1973; Wydoski and Whitney 2003). Although males remain at the spawning site well after females, it is thought they remain to spawn with other females as opposed to engaging in nest-guarding behavior (Wydoski and Whitney 2003). Prior to spawning, male lower fin insertions and lips change color to orange or scarlet; whereas both male and female leopard dace develop breeding tubercles on the head and body (Peden 1991; Wydoski and Whitney 2003). Spawning takes place between May and July (Wydoski and Whitney 2003).

JUVENILES

Young of the year mostly feed on dipterous larvae (Ephemeroptera and Diptera) until age one when their diet shifts to terrestrial insects (Froese and Pauly 2004). Juveniles have been observed to migrate to deeper water at night effectively changing positions with adults who move to shallower water (Peden 1991), although the purpose of these nocturnal movements is not well understood.

4-14.5 Population Trends

Insufficient information exists regarding past and current abundance to draw conclusions regarding population trends. Washington Fish and Wildlife is currently continuing its efforts to determine the population trends and status of leopard dace in Washington.

4-14.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Since leopard dace are dependent on river and stream shoreline habitat, they are vulnerable to a number of impacts affecting their habitat. Sand and gravel mining, logging, agriculture, grazing or urbanization may increase sediment deposition, which degrades habitat. Shoreline armoring and fill may decrease critical areas of shallow, slow moving habitat. Furthermore, shoreline development, grazing and agriculture may decrease both riparian cover and terrestrial insects that are important prey items for dace. Bank armoring impacts dace by removing refuge from predators found with undercut banks, log snags, and streamside vegetation. The removal of woody debris from rivers, streams and estuaries to improve navigability, decrease channel meander, and aesthetically improve “views” has resulted in a significant loss of refuge from predators and may increase scour from high flow events caused by water releases from dams and flooding. Point source and non-point source pollution can have deleterious effects on food web assemblages and individuals.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

There are no known commercial, recreational, scientific or educational uses for leopard dace.

DISEASE OR PREDATION

Although dace likely serve as forage fish for trout, salmon, and other native and introduced fishes, insufficient information exists to determine that disease or predation is a current threat to leopard dace survival. However, it is important to note that small isolated populations can be highly sensitive to disease events or an increase in predation rates from native or introduced predators.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Leopard dace may be at risk due to the inadequacy of regulatory mechanisms regarding habitat loss and degradation such as changes in sediment load, fill and bank armoring, point and non-point source pollution, and water diversions.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Temperature change brought about by local land and watershed management that decreases riparian zone shading and cover, as well as broader scale factors such as global climate change may negatively impact leopard dace populations. Furthermore, isolated stocks may not be able to effectively restock weakened populations due to habitat separation caused by dams. Low-density populations may also decline due to the inability to find mates; which may place isolated populations at further risk of extirpation.

4-14.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Leopard dace are likely to be affected by a variety of activities authorized by Washington DNR on state-owned rivers. In addition to providing a refuge for predators, overwater structures frequently reduce or prevent the growth vegetated habitat by preventing the transmission of light. Outfalls may cause localized reductions in water and sediment quality, resulting in increased turbidity, reduced foraging efficiency, diminished habitat quality, and potential bioaccumulation of pollutants. Construction of roads and bridges may result in increased sedimentation during construction, as well as increase temperature and pollutant loads from stormwater runoff during operation. Pollutants that are harmful to dace and that are present in stormwater runoff and outfalls include but are not limited to hormones, PCBs, heavy metals, salts, fertilizers, and petroleum products. Dredging, fill, shoreline armoring, and sand and gravel mining may either remove habitat or prevent the formation of habitat, or alter sediment loads, thereby decreasing habitat through increased scour or deposition. Aquaculture operations also have the potential to impact this species through disease transmission, decreased dissolved oxygen levels, increases in nitrogenous waste and the introduction of chemicals such as, pesticides and antibiotics.

4-14.8 Species Coverage Recommendation and Justification

It is recommended that leopard dace be addressed as an **Evaluation Species** for the following reasons: 1) Although leopard dace are not federally listed, Washington Fish and Wildlife lists the leopard dace as a Candidate Species; 2) Washington DNR authorized activities have a “high” potential to affect leopard dace; and 3) Insufficient information exists to assess impacts and to develop conservation measures.

4-14.9 References

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4-15 Olympic mudminnow

4-15.1 Species Name

Novumbra hubbsi

Common Name: Olympic mudminnow

Initial coverage recommendation: Evaluation

4-15.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not Listed

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Sensitive

NATURAL HERITAGE PROGRAM GLOBAL RANK

G3

NATURAL HERITAGE PROGRAM STATE RANK

S2, S3

4-15.3 Range

The Olympic mudminnow is endemic to western Washington. The species is well documented, occurring in the southern and western lowlands of the Olympic Peninsula, the Chehalis River drainage, lower Deschutes River drainage and South Puget Sound lowlands west of the Nisqually River (Mongillo and Hallock 1999). However, recent observations have extended their range into the Cherry and Issaquah Creek drainages (Trotter et al. 1998). Because of the elevation at which these populations are found (240 and 135 meters receptively), there is debate as to whether they are naturally occurring or introduced (Trotter et al. 1998; Mongillo and Hallock 1999). More than 96 percent of Olympic mudminnows are found at elevations less than 100 meters above sea level (Mongillo and Hallock 1999). A figure representing the distribution of the Olympic mudminnow in Washington may be found in Appendix F.

4-15.4 Habitat Use

Olympic mudminnows are found mostly in riverine, palustrine and lacustrine wetland habitats. They have also been found in other still-waters habitats such as the littoral areas of lakes, backwater areas of low gradient valley streams and possibly in riffle-pool habitats. According to Harris (1974), Olympic mudminnows are closely associated with three essential habitat characteristics: 1) a soft mud bottom at least several centimeters in depth; 2) little or no flow; and 3) dense aquatic vegetation. He further stated that if any of these characteristics were missing, mudminnows were not found. A study conducted by Washington Fish and Wildlife (Mongillo and Hallock 1999) at a site in Lake Ozette found that the species was present immediately after vegetation was removed, however the minnows were not present in later surveys. As the vegetation returned, so did Olympic mudminnows.

Spawning occurs from late November to mid June, with a peak during April and May. Water temperature during spawning ranges from 10 to 18° Celsius. Eggs are usually deposited near the bottom and no parental care of eggs or fry is given. In laboratory conditions with water temperatures between 15 to 17° Celsius, eggs hatch within nine days, and fry disperse about seven days after hatching (Mongillo and Hallock 1999).

Olympic mudminnow prey items includes a variety of invertebrate species including those from the following families; Ostracoda, Isopoda, Oligochaeta, Mysidacea, Megaloptera, Mollusca, and Diptera (Mongillo and Hallock 1999). While little is known about predators of this species, it is likely that fish, birds, and mammals prey upon them. In a study of fishes in oxbow lakes in Washington, Beecher and Fernau (1983) noted that Olympic mudminnows were not found in lakes that contained non-native fish predators.

4-15.5 Population Trends

While historic data on Olympic mudminnow population status is not available, several studies have documented the dependence of Olympic mudminnow on wetland habitats. Because of the widespread loss of wetlands within the Olympic mudminnow range, it is reasonable to conclude that the overall population size is likely smaller than prior to Euro-American settlement. Olympic mudminnows are locally common within the known range, with a recent population study conducted at 16 sites between 1993 and 1998 that showed 14 populations appear to be stable and two are at risk. Even if present populations are healthy, the distribution of the Olympic mudminnow is extremely restricted, and local disturbances may have profound effects on its persistence (Mongillo and Hallock 1999).

4-15.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Threats to the Olympic mudminnow include, but are not limited to, any form of wetland degradation (natural or anthropogenic) that alters or eliminates mud substrate or aquatic vegetation, increases water flow or degrades water quality. Because of the Olympic mudminnow's limited range, further habitat modification or reduction could critically impair the long term survival of the species (Harris 1974; Mongillo and Hallock 1999). Residential and commercial development may also impact these fish by draining or channeling wetlands resulting in a direct loss of suitable habitat.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

The Olympic mudminnow is not a sought-after game fish and has no commercial value. Therefore, there are no harvest-related issues (Mongillo and Hallock 1999). In addition, there are no known scientific or educational uses for Olympic mudminnows.

DISEASE OR PREDATION

Little information exists concerning the impact of disease or predation on Olympic mudminnow populations. However, a study conducted by Beecher and Fernau (1983) examined fish populations in 16 oxbow lakes and found that Olympic mudminnows are absent in sites that include exotic fish predators.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Although not a protected species under federal or state regulatory requirements, the needs of the Olympic mudminnow are often taken into account when a proposed project may impact its habitat. However, recommendations for protection are often only advisory and these measures typically offer limited protection (Mongillo and Hallock 1999). State and federal regulations that may provide direct protection to this species habitat include Washington State's Growth Management, Shoreline Management and Water Pollution Control Acts, and the Federal Clean Water and the Food Security Act.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Alterations to habitat designed to enhance salmon habitat and eliminate mud substrate and vegetation or increase water flow may be in conflict with Olympic mudminnow habitat requirements (Mongillo and Hallock 1999).

4-15.7 Assessment of Potential Effects from Washington DNR Authorized Activities

The Olympic mudminnow is likely to be affected by a variety of activities authorized by Washington DNR on state-owned rivers and lakes. In addition to providing a refuge for predators, overwater structures frequently reduce or prevent the growth vegetated habitat by preventing the transmission of light. Outfalls may cause localized reductions in water and sediment quality, resulting in increased turbidity, reduced foraging efficiency, diminished habitat quality, and potential bioaccumulation of pollutants. Construction of roads and bridges may result in increased sedimentation during construction, as well as increase temperature and pollutant loads from stormwater runoff during operation. Pollutants that are harmful to dace and that are present in stormwater runoff and outfalls include but are not limited to hormones, PCBs, heavy metals, salts, fertilizers, and petroleum products. Dredging, fill, shoreline armoring, and sand and gravel mining may either remove habitat or prevent the formation of habitat, or alter sediment loads, thereby decreasing habitat through increased scour or deposition. Aquaculture operations also has the potential to impact this species through disease transmission, decreased dissolved oxygen levels, increases in nitrogenous waste and the introduction of chemicals such as, pesticides and antibiotics.

4-15.8 Species Coverage Recommendation and Justification

It is recommended that the Olympic mudminnow be addressed as an **Evaluation Species** for the following reasons: 1) The species is not currently federally listed, yet it is listed as a Sensitive Species in Washington; 2) Olympic mudminnows are dependent on wetland, littoral lake and low gradient valley stream habitats, and have a “high” potential to be affected by activities authorized by Washington DNR; 3) Sufficient information exists to assess impacts and to develop conservation measures.

4-15.9 References

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Draft

4-16 Pygmy Whitefish

4-16.1 Species Name

Prosopium coulteri

Common Name: Pygmy whitefish

Initial coverage recommendation: Covered

4-16.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not listed

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Sensitive

NATURAL HERITAGE PROGRAM GLOBAL RANK

G5

NATURAL HERITAGE PROGRAM STATE RANK

S1, S2

4-16.3 Range

The pygmy whitefish is a freshwater fish of the family Salmonidae, subfamily Coregoninae and is often confused with the young of a close relative, the mountain whitefish (*Prosopium williamsoni*) (Mackay 2000). Relict populations of pygmy whitefish from the last Pleistocene Ice Age are found in deep lakes throughout northern North America, but have also been found in one lake in Russia (Hallock and Mongillo 1998; Wydoski and Whitney 2003). In North America, they are distributed within the northern portion of the United States (Lake Superior, Montana and Idaho), throughout western Canada (British Columbia, Saskatchewan and the Northwest Territories), and into southeast Alaska. Wydoski and Whitney (2003) note that the pygmy whitefish may actually occur more widely than is currently reported because of the likelihood that targeted sampling with deepwater gear probably has not been intensive.

Pygmy whitefish in Washington State are found at the extreme southern edge of their natural range. According to a survey conducted by the Washington State Department of Fish and Wildlife (Washington Fish and Wildlife) between 1993 and 1997, pygmy whitefish were once found in at least 15 Washington lakes but have a current distribution in 9 (Hallock and Mongillo 1998; Wydoski and Whitney 2003) (Table 1) (Appendix F). All remaining populations in Washington State are believed to have been identified (Hallock and Mongillo 1998).

Table 4-16.1

Lakes where pygmy whitefish were historically found in Washington State, with indication of current presence

Lake	County	Current Presence
Bead	Pend Oreille	X
Buffalo	Okanogan	
Chelan	Chelan	X
Chester Morse	King	X
Cle Elum	Kittitas	X
Crescent	Clallam	X
Diamond	Pend Oreille	
Horseshoe	Pend Oreille	
Kachess	Kittitas	X
Keechelus	Kittitas	X
Little Pend Oreille Lakes	Stevens	
Marshall	Pend Oreille	
North Twin	Ferry	
Osoyoos	Okanogan	X
Sullivan	Pend Oreille	X

4-16.4 Habitat Use

ADULT

Pygmy whitefish most often occur in deep, oligotrophic (unproductive) lakes where temperatures are 10° Celsius or lower (Wydoski and Whitney 2003), with Canadian studies noting that they are also typically found in some fast, cold mountain streams (Mackay 2000). Although adults are generally found in deepwater lake habitats, they may move into shallow water or tributary streams during the spawning season (Hallock and Mongillo 1998). Adult pygmy whitefish have also been collected in the surface waters of some lakes (Hallock and Mongillo 1998).

Pygmy whitefish feed primarily during daylight hours on zooplankton, such as cladocerans, copepods, and midge larvae, as well as small molluscs and fish eggs (Wydoski and Whitney 2003). Two forms, bottom feeders and plankton feeders, have been described in some Alaska lakes.

While the species is classified as a coldwater stenotherm (narrow range of temperature requirements), temperature and dissolved oxygen requirements have not been determined

(Hallock and Mongillo 1998). This species is slow growing, with a maximum recorded age of 9 years and lengths under 29 centimeters (Wydoski and Whitney 2003). In Washington, two of the most common fishes co-occurring with pygmy whitefish are kokanee (*Oncorhynchus nerka*) and rainbow trout (*Oncorhynchus mykiss*) (Hallock and Mongillo 1998).

SPAWNING/INCUBATION/EMERGENCE

Pygmy whitefish mature at an early age (age 1 to 4 years), with males maturing earlier than females (Wydoski and Whitney 2003). They spawn at night from late summer to early winter along the shoreline of lakes or in the riffles of tributary streams, with timing dependent on geographic location and elevation (Hallock and Mongillo 1998). Spawning substrate is likely coarse gravel or rocky material, with individuals from Chester Morse Lake observed spawning in pools just below riffles in lake tributaries (Cedar and Rex Rivers) during late December and early January (Hallock and Mongillo 1998; Wydoski and Whitney 2003).

JUVENILE

Juvenile pygmy whitefish from a lake in Alaska were found primarily in open water and nearshore habitats (Hallock and Mongillo 1998). No other published information on juvenile habitat was found in the literature.

4-16.5 Population Trends

In Washington State, the current population status of pygmy whitefish is unknown (Hallock and Mongillo 1998). In general, pygmy whitefish are not common and too few have been collected to establish any firm data on population status or trends (Mackay 2000). Although new observations of this species are occurring across their range, it is believed that all remaining populations in Washington State have been identified. Use of piscicides (chemicals used to kill fish), combined with the introduction of non-native fish predators (e.g., smallmouth bass, *Micropterus dolomieu*), is thought to have extirpated a number of isolated lake populations (Hallock and Mongillo 1998).

4-16.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Because pygmy whitefish in Washington State are limited to 9 remaining populations in lakes with fairly specific conditions (high oxygen, low temperature and low nutrients), they are vulnerable to threats associated with habitat destruction and alteration. These threats include eutrophication, siltation and increased water temperatures associated with logging, agriculture, grazing and urban/suburban development in riparian habitats (Hallock and Mongillo 1998). However, habitat associated with the existing lake

populations is generally considered stable because most is owned by various government agencies or public utilities (Hallock and Mongillo 1998).

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC, OR EDUCATIONAL PURPOSES

Over utilization has not been cited as a threat to pygmy whitefish (Hallock and Mongillo 1998).

DISEASE OR PREDATION

Although disease has not been cited as a threat to pygmy whitefish, predation by non-native species is thought to have contributed to the extirpation of some populations (Hallock and Mongillo 1998).

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Pygmy whitefish are listed as a Priority species under Washington's Priority Species and Habitat Program, which provides some protection under existing regulatory mechanisms (Hallock and Mongillo 1998). The species may also receive some protection through the Washington Forest Practices Act, other salmonid protection programs, and the Aquatic Species Nuisance Plan (Washington Aquatic Nuisance Species Coordinating Committee 2001).

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

While past use of piscicides has resulted in the extirpation of some Washington State pygmy whitefish populations, the future use of these chemicals is not considered likely (Hallock and Mongillo 1998). Although unstudied, the effects of warming temperatures associated with global climate change may force habitat shifts by pygmy whitefish that could result in competition with other species and/or extirpation from existing habitat (Mackay 2000).

4-16.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Pygmy whitefish are likely to be affected by any activity authorized by Washington DNR within their known range; in lakes where the species may have historically occurred and may be reestablished (e.g., Marshall Lake); and in the surrounding watersheds of existing or potential habitat (Hallock and Mongillo 1998). Discharges from outfalls may lead to increased eutrophication, siltation, and/or water temperatures; while overwater structures and bank armoring may alter shallow lake and stream tributary habitats. Nearshore and transportation-related activities (e.g., fill and bank armoring, sediment disturbance, utility line construction) can alter shallow water lake and stream tributary habitat. Aquaculture may also increase eutrophication or introduce invasive species, and the use of piscicides to control invasive species may directly impact pygmy whitefish.

4-16.8 Species Coverage Recommendation and Justification

It is recommended that pygmy whitefish be addressed as an **Evaluation species** for the following reasons: 1) Although the species is not federally listed, it is currently considered a State Priority species; 2) Activities authorized by Washington DNR activities have a “medium” potential to affect Pygmy whitefish; and 3) Insufficient information is available to assess impacts and to develop conservation measures.

4-16.9 References

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4-17 Umatilla Dace

4-17.1 Species Name

Rhinichthys umatilla

Common Name: Umatilla dace

Umatilla dace are members of the genus *Rhinichthys* and are morphometrically similar to leopard dace *Rhinichthys falcatus*. Umatilla and leopard dace were previously considered to be sub-species of the taxonomically similar speckled dace (Wydoski and Whitney 2003), with the American Fisheries Society only recently recognizing the Umatilla dace as a valid species (Nelson et al. 2004). Umatilla and leopard dace exhibit only small morphological differences such as the absence of fleshy stays on the rays of the pelvic fins, the presence of all but connected dark spots along the lateral line, a wider caudal peduncle and smaller, more numerous, lateral line scales (Wydoski and Whitney 2003). Umatilla dace also exhibit different habitat usage than Leopard dace, opting for slower currents typically found in glides (Haas 1999). Although hybridization is possible between speckled, leopard, and Umatilla dace, genetic differences reveal that Umatilla dace are not early generation hybrids of Leopard and speckled dace (Haas 2001). Previous research has indicated that Umatilla dace are intermediate between speckled and leopard dace in morphometry, distribution, and ecology (Haas 2001). It has been suggested that Umatilla dace have evolved from an ancient hybridization of leopard and speckled dace that occurred directly after the last Pleistocene glaciation (Haas 2001).

Initial coverage recommendation: Covered

4-17.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL

Not listed

WASHINGTON FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

G4

NATURAL HERITAGE PROGRAM STATE RANK

S2

4-17.3 Range

Umatilla dace populations are sporadic and disconnected, occurring throughout North America in British Columbia, Idaho, Oregon and Washington. In Washington the species is found in the Columbia Basin above the Dalles Dam, in the Upper reaches of the Yakima river, and in the Similkameen, Colville, Methow and Wenatchee rivers (Peden and Hughes 1988; Haas 2001; Wydoski and Whitney 2003) (Appendix F).

4-17.4 Habitat Use

ADULTS

Umatilla dace are benthic and prefer productive, low elevation streams with currents strong enough to contain clean gravel. Although early studies (Peden and Hughes 1988; Peden 1991) suggested that Umatilla dace occupy positions with higher velocities than leopard dace, evidence from a recent study indicates the opposite (Haas 2001). Umatilla dace are found at depths less than 1 meter, in substrates comprised of rock, boulder and cobble (Wydoski and Whitney 2003). Individuals may live as long as 4 years in the wild and attain lengths of approximately 10 centimeters (Haas 2001; Wydoski and Whitney 2003). While prey preferences are unknown, they are assumed to feed on aquatic insects similarly to other dace species (Wydoski and Whitney 2003).

SPAWNING

Although little is known regarding spawning behavior, Umatilla dace may utilize habitat similar to other dace species, spawning over unprepared gravel or small stones in riffles. In Washington, it is believed that spawning occurs in early to mid-July (Wydoski and Whitney 2003).

JUVENILES

Little is known regarding the diet of juvenile Umatilla dace yet it likely mirrors that of other dace, which consists of aquatic insect larvae. Juveniles are likely found in slow-moving backwater pools of less than 0.5 meter in depth (Haas 2001) with cobble substrates covered with algae (Wydoski and Whitney 2003).

4-17.5 Population Trends

Insufficient information exists regarding past and current abundance to draw conclusions regarding population trends. In 1998, due to its unknown status and an irregular distribution, the Umatilla dace was listed as a state Candidate Species by Washington Fish and Wildlife (Mongillo and Hallock 1999). Washington Fish and Wildlife is currently continuing its efforts to determine whether Umatilla dace should be listed as an Endangered, Threatened or Sensitive species in Washington.

4-17.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Umatilla dace are dependent on river and stream shoreline habitat, they are vulnerable to a number of impacts affecting their habitat. Sand and gravel mining, logging, agriculture, grazing or urbanization may increase sediment deposition, which degrades habitat. Shoreline armoring and fill may decrease critical areas of shallow, slow moving habitat. Furthermore, shoreline development, grazing and agriculture may decrease both riparian cover and terrestrial insects that are important prey items for dace. Bank armoring impacts dace by removing refuge from predators found with undercut banks, log snags, and streamside vegetation. The removal of woody debris from rivers, streams and estuaries to improve navigability, decrease channel meander, and aesthetically improve “views” has resulted in a significant loss of refuge from predators and may increase scour from high flow events caused by water releases from dams and flooding. Point source and non-point source pollution can have deleterious effects on food web assemblages and individuals.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

There are no known commercial, recreational, scientific or educational uses for Umatilla dace.

DISEASE OR PREDATION

Although dace likely serve as forage fish for trout, salmon, and other native and introduced fishes, insufficient information exists to determine that disease or predation is a current threat to Umatilla dace survival. However, it is important to note that small, isolated populations can be highly sensitive to disease events or an increase in predation rates from native or introduced predators.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Umatilla dace may be at risk due to the inadequacy of regulatory mechanisms regarding habitat loss and degradation such as changes in sediment load, fill and bank armoring, point and non-point source pollution and water diversions.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Temperature change brought about by local land and watershed management that decreases riparian zone shading and cover, as well as broader scale factors such as global climate change may negatively impact Umatilla dace populations. Furthermore, isolated stocks may not be able to effectively restock weakened populations due to habitat separation caused by dams. Low-density populations may also decline due to the inability to find mates; which may place isolated populations at further risk of extirpation.

4-17.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Umatilla dace are likely to be affected by a variety of activities authorized by Washington DNR on state-owned rivers. In addition to providing a refuge for predators, overwater structures frequently reduce or prevent the growth vegetated habitat by preventing the transmission of light. Outfalls may cause localized reductions in water and sediment quality, resulting in increased turbidity, reduced foraging efficiency, diminished habitat quality, and potential bioaccumulation of pollutants. Construction of roads and bridges may result in increased sedimentation during construction, as well as increase temperature and pollutant loads from stormwater runoff during operation. Pollutants that are harmful to dace and that are present in stormwater runoff and outfalls include but are not limited to hormones, PCBs, heavy metals, salts, fertilizers, and petroleum products. Dredging, fill, shoreline armoring, and sand and gravel mining may either remove habitat or prevent the formation of habitat, or alter sediment loads, thereby decreasing habitat through increased scour or deposition. Aquaculture operations also has the potential to impact this species through disease transmission, decreased dissolved oxygen levels, increases in nitrogenous waste and the introduction of chemicals such as, pesticides and antibiotics.

4-17.8 Species Coverage Recommendation and Justification

It is recommended that Umatilla dace be addressed as an **Evaluation Species** for the following reasons 1) Although Umatilla dace are not federally listed, Washington Fish and Wildlife lists the Umatilla dace as a Candidate Species. 2) Washington DNR authorized activities have a “high” potential to affect Umatilla dace. 3) Insufficient information exists to assess impacts and to develop conservation measures.

4-17.9 References

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Wydoski, R.S. and R.L. Whitney. 2003. Inland Fishes of Washington. University of Washington Press. Seattle, Washington

Draft

4-18 Margined Sculpin

4-18.1 Species Name

Cottus marginatus

Common Name: Margined sculpin

Initial coverage recommendation: Covered

4-18.2 Status and Rank:

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Species of Concern

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Sensitive Species

NATURAL HERITAGE PROGRAM GLOBAL RANK

G3

NATURAL HERITAGE PROGRAM STATE RANK

S1

4-18.3 Range

The margined sculpin is endemic to Washington and Oregon (Wydoski and Whitney 2003). While its historic distribution is unknown, it is currently found in headwater tributaries of the Columbia River within the Blue Mountains. In Washington, it is only found in parts of the Tucannon, Touchet and Walla Walla drainages (Mongillo and Hallock 1998; Wydoski and Whitney 2003) (Appendix F).

4-18.4 Habitat Use

Margined sculpin can be found in stream pools where water temperature may reach 20° Celsius (Mongillo and Hallock 1998). The species prefers small gravel and silt substrates, with adults typically found in deeper, faster water than juveniles (Mongillo and Hallock 1998; Wydoski and Whitney 2003). While little is known regarding the species' life history and habitat requirements, it is likely that spawning occurs in the spring under rocks similar to that of other sculpin species (Wydoski and Whitney 2003). Spring spawning is implied by the presence of young of the year in fall electro-fishing surveys (Mongillo and Hallock 1998). Prey items are also likely similar to those of other sculpins, with the species opportunistically consuming aquatic insects, crustaceans, other fish eggs and larvae and terrestrial insects (Wydoski and Whitney 2003). Margined sculpins co-occur with rainbow, bull and brook trout, chinook and speckled dace (Wydoski and Whitney 2003).

4-18.5 Population Trends

The past and current population status of the margined sculpin is unknown, however it is locally common within the known range. Even if present populations are healthy, its extremely restricted distribution poses concern for the future as local disturbances may have profound effects on its persistence (Mongillo and Hallock 1998). In addition, much of its habitat is degraded and faces an uncertain future. Because of its small range and degraded habitat conditions, it is vulnerable and likely to become Threatened or Endangered in a significant portion of its range without cooperative management (Mongillo and Hallock 1998).

4-18.6 Assessment of Potential Effects from Washington DNR Authorized Activities

Currently the distribution of the margined sculpin in Washington state is limited to a distinct geographic region that does not include state owned aquatic lands. Therefore, the probability of adverse impacts to margined sculpins resulting from activities authorized by Washington DNR is extremely low.

4-18.7 Species Coverage Recommendation and Justification

It is recommended that the margined sculpin be considered a **Watch-list Species** because: 1) It is federally listed as a Species of Concern; 2) Washington DNR activities have an extremely “low” potential to affect the margined sculpin because the species is

only found in higher order streams that are generally not navigable and therefore unlikely to be state-owned aquatic lands; and 3) There is enough information to assess the potential impacts from Washington DNR activities and to develop conservation measures.

4-18.8 References:

Mongillo, P. E. and M. Hallock. 1998. Washington State Status Report for the Margined Sculpin. Washington Department of Fish and Wildlife. Olympia, Washington.

Wydoski, R.S. and R.L. Whitney. 2003. Inland Fishes of Washington. University of Washington Press. Seattle, Washington.

4-19 Westlope Cutthroat Trout

4-19.1 Species Name

Oncorhynchus clarki lewisi

Common Name(s): Westslope cutthroat trout and inter-mountain cutthroat trout

Initial coverage recommendation: Covered

4-19.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Species of Concern

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Species of Concern

NATURAL HERITAGE PROGRAM GLOBAL RANK

G4, T3

NATURAL HERITAGE PROGRAM STATE RANK

S?

4-19.3 Range

Westslope cutthroat trout are found in many eastern Washington lakes and streams and are also stocked in many high-country lakes, including some lakes west of the Cascade Crest (Downen 2004; Washington Fish and Wildlife 2005) most of which are small, isolated water bodies in mountainous areas (US Fish and Wildlife 2000). A figure representing the distribution of westslope cutthroat trout in Washington may be found in Appendix F.

4-19.4 Habitat Use

Like other salmonids in the Pacific Northwest, good water quality, low nutrients, and low water temperatures are generally preferred habitats, especially for spawning and rearing. Besides the high mountain lakes, they are often found in the well-oxygenated waters of headstream and tributaries (Washington Fish and Wildlife 1992), where adults tend to prefer deeper water than do juveniles, and are often found in the same streams with other species, such as bull trout and mountain whitefish.

4-19.5 Population Trends

It is now estimated that in Washington State alone the westslope cutthroat trout are found in more than 493 streams and 311 lakes (Fuller 2002 in US Fish and Wildlife 2003). Because of stocking programs, mostly in the twentieth century, it is estimated that the westslope cutthroat trout are more widely distributed today than prior to European settlement (US Fish and Wildlife 1999). Throughout its current range, westslope cutthroat trout are found in approximately 4,275 tributaries comprised of more than 23,000 linear miles of stream habitat in 12 major drainages within the Columbia, Missouri, and Saskatchewan River basins (US Fish and Wildlife 2000). Because most of the land in which the majority of the westslope cutthroat are found is controlled by federal agencies and many areas are roadless or designated wilderness areas, several layers of protection already exist for the westslope cutthroat trout (US Fish and Wildlife 1999).

4-19.6 Species Coverage Recommendation and Justification

It is recommended that westslope cutthroat trout be addressed as a **Watch-list Species** because: 1) The subspecies is listed as a federal and state Species of Concern; 2) Washington DNR authorized activities have a “low” potential to affect westslope cutthroat trout because the subspecies occurs in small, isolated water bodies in mountainous areas, most of which are in designated roadless or wilderness areas; and 3) Sufficient information exists to assess impacts and develop conservation measures.

4-19.7 References

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U.S. Fish and Wildlife Service. 2000. Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) Fact Sheet. Accessed 22 March 2005. <http://mountain-prairie.fws.gov/species/fish/wct/fact.htm>

U.S. Fish and Wildlife Service. 2003. Remanded Administrative Finding Memorandum, August 2003. Available at: http://mountain-prairie.fws.gov/species/fish/wct/remanded_12month.pdf

Washington Department of Fish and Wildlife. 1992. Historic Archives, Cutthroat Trout,. Accessed 22 March 2005. <http://wdfw.wa.gov/archives/pdf/94021371.pdf>

Washington Department of Fish and Wildlife. 2005. Youth Fishing. Accessed March 22, 2005. <http://wdfw.wa.gov/fish/youth/what.htm>

4-20 Black Rockfish

4-20.1 Species Name

Sebastes melanops

Common Name: Black rockfish

Initial coverage recommendation: Evaluation

4-20.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not listed

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Not Ranked

NATURAL HERITAGE PROGRAM STATE RANK

Not Ranked

4-20.3 Range

Black rockfish range from Amchitka Island, Alaska, to Huntington Beach, in southern California, though they may have been historically present in Baja California, Mexico (Hart 1973; Love et al. 2002). They are most abundant from northern California to southeast Alaska in water less than 200 meters in depth, though they have been found deeper (Hart 1973).

Black rockfish are found along the outer coast of Washington, in the Strait of Juan de Fuca, and are common in Puget Sound. They are most prevalent in depths from 50 to 100 meters, with juveniles common in kelp beds and nearshore areas. Ideal habitat (consolidated with much structure) is found north of Destruction Island to Cape Flattery, within 200 meters of the shore (Boettner and Burton 1990). Information regarding the

geographic distribution of black rockfish for all life stages is incomplete, therefore no species distribution map is presented for this species.

4-20.4 Habitat Use

ADULT

Adult black rockfish occupy a variety of habitats, including caves and crevices in high- and low-relief areas, kelp beds. They are known to be pelagic, forming loose schools in the water column. Often they are inactive at night, settling on the bottom among rocks (Love et al. 2002). Divers in Puget Sound have observed black rockfish resting on the substrata. In a study by Boettner and Burton (1990), hydroacoustic surveys confirmed black rockfish schooling behavior and their tendency to aggregate near the bottom in association with rocky substrate.

Studies of adult black rockfish movement via mark-recapture tagging studies have provided mixed results, with some fish migrating large distances and others remaining close to the release point. Most studies have shown little migratory behavior, with tagged fish often staying within a few kilometers of the release point (Culver 1986). Other studies have shown black rockfish to be highly mobile, ranging hundreds of kilometers along the coast (Coombs 1979; Lai and Culver 1990).

Black rockfish are opportunistic predators, feeding mainly on pelagic zooplankton such as squid, euphausiids and crab larvae, herring and other bait fish (Stein and Hassler 1989; Love et al. 2002), and juvenile rockfishes (Hobson et al. 2001). They can engage in feeding aggregations near the surface of the water (Love et al. 2002).

Adult black rockfish can live to 50 years of age (Wallace et al. 1999). As is common with rockfish, sexual maturity occurs at different ages for males and females, with males maturing as early as 3 years, and females maturing on average at 7.5 years (Bobko and Berkeley 2004).

REPRODUCTION

Mating occurs once a year, generally in the fall. Black rockfish, like other *Sebastes* species, are ovoviviparous, producing live young. Additionally, black rockfish are known to be matrotrophically viviparous, which means that in addition to nutrients in the yolk, their embryos derive further nutrients directly from the mother (Shimuzu et al. 1991). Females can store sperm for several months while their eggs develop; fertilization occurs from December through February (Bobko and Berkely 2004). Females can produce more than 1 million eggs per season, with older fish producing more eggs (Bobko and Berkeley 2004). Bobko and Berkeley (2004) verified that black rockfish followed the same pattern shown in previous studies (e.g., Gunderson et al. 1980, Cooper 2003) indicating increasing fecundity with age among many rockfish species.

Parturition occurs offshore between January and March, with older, more fecund fish releasing larvae earlier (Bobko and Berkeley 2004). On the Oregon coast, spent females were first found in January but were most common in February and March (Bobko and Berkely 2004). There is evidence that some females may reabsorb some of their eggs;

the exact reason is unknown, but it is likely that these eggs were not fertilized (Love et al. 2002). Larvae are about 5 millimeters in length at parturition (Stein and Hassler 1989).

LARVAE AND JUVENILES

Larvae are thought to be released offshore and have been observed associated with kelp mats and other floating debris (Love et al. 2002). As they grow, larvae migrate toward shore and settle at approximately 50 millimeters length (Stein and Hassler 1989; Love et al. 2002). They are often associated with kelp beds, eelgrass, or other structures, such as rocky reef or man-made material.

After settling (often between May and July), black rockfish juveniles stay in shallow, nearshore waters and occasionally in estuaries or tide pools (Boehlert and Yoklavich 1983; Love et al. 2002). Juvenile mortality immediately after settlement is high, and decreases as juveniles grow in size and density dependent predators switch to other prey items (Hobson et al. 2001). As they grow, they tend to inhabit deeper water habitats, occupying crevices and rocky holes.

4-20.5 Population Trends

Since the early 1980s, black rockfish, along with several other species, have experienced population declines. Black rockfish are not a common component of commercial groundfish fisheries because their offshore habitat is prohibitive for fishing gear (bottom trawls). For example, in 1999 in Alaska, hook and line landed 118 metric tons of black rockfish, whereas only 1 metric ton was captured in trawls during this same period. In Washington, black rockfish were considered “other rockfish” and, therefore, estimates are imprecise, though the trend is likely similar (Pacific States Marine Fisheries Commission 1999).

Some fish are taken commercially, especially for the live-fish fisheries in California, by hook and line (Love et al. 2002). Some loss is a result of incidental take from commercial salmon trolling or other commercial activities. However, it is estimated that black rockfish make up about half of the total groundfish catch in Oregon’s recreational fishery (Love et al. 2002). Trends in Washington are likely similar. Wallace et al. (1999) assessed the status of black rockfish off the coast of Washington and concluded that the black rockfish stock can be characterized as “declining in abundance but healthy, i.e., displaying abundance levels in excess of those assumed to promote sustainable production.” It is important to note that black rockfish are managed (and assessed) as part of a rockfish complex, and data on individual species trends within the complex are lacking. Few data exist for current populations in Puget Sound.

In recreational fisheries, larger, more fecund fish are preferred by recreational anglers and are being removed from the fishery at higher rates than smaller fish, truncating the population age composition (Coleman et al. 2004). Not only does this practice result in removal of biomass from the population, but more importantly, it jeopardizes the reproduction potential (Bobko and Berkely 2004).

4-20.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Black rockfish inhabit nearshore and offshore consolidated habitats, which are not at high risk of destruction or modification. However, black rockfish are found in shallower water than other rockfish species, so shore-related activities, such as overwater structures, port development or other construction that extends into the intertidal zone may impact this species. Black rockfish tend to associate with structure (both natural and man-made) in the nearshore and may be drawn to features such as pilings, floating structures and in-water debris. Kelp and eelgrass have been identified as important nearshore habitats for rockfishes, especially juveniles (Murphy et al. 2000). Destruction of kelp and eelgrass habitats may also have trophic impacts for this species.

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Black rockfish have been targeted in recreational and commercial fisheries. As with other rockfish species, their population has declined during the last 50 years. However, much of this decline is likely due to recreational fishing rather than commercial trawling. Larger, more fecund fish are being removed from the fishery at the highest rates, narrowing the population age composition, which influences the production of the species in future generations (Coleman et al. 2004). Although stock assessments of coastal populations show populations (spawning biomass) to be healthy, downward trends are also noted (Wallace et al. 1999) and may be cause for more intensive management actions.

DISEASE OR PREDATION

Neither disease nor predation has been identified as significant threats to the species.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Recreational and live-fish commercial fisheries have had the greatest impact on black rockfish populations. Black rockfish are tightly linked to rocky, consolidated habitats, so are more difficult to target in commercial fisheries (trawls) than are neritic or benthopelagic species, such as widow and canary rockfish, which perhaps alleviates some of the commercial pressure other species have faced. The Puget Sound Groundfish Management Plan aims to manage rockfish in a sustainable manner (Palsson et al. 1998). However, the overall trend in declining populations suggests that stricter regulation of the recreational fishery may be necessary, especially to keep larger, more fecund fish as part of the spawning biomass. Because of the nature of rockfish swimbladders, catch-and-release regulations are difficult—when caught, rockfish usually suffer trauma from increases in dissolved gases in their blood upon surfacing.

Additionally, little is known about the specific ecology of individual rockfish species including larval and juvenile ecology, food habits or how oceanic conditions impact

recruitment (Harvey 2005). Further study is needed to adequately manage rockfish species.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Recreational and commercial take, especially of the largest and oldest fish, are the most significant concerns for rockfish. Because black rockfish, especially as juveniles, are closely associated with nearshore areas, shore-based human activities, such as construction of piers, ports and bridges, as well as associated pollution, are more likely to affect this species than others. Because of the small home range of black rockfish, marine protected areas may be a viable management alternative for this species.

4-20.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Black rockfish are likely to be affected by activities authorized by Washington DNR within marine nearshore environments. Roadways, bridges, and docks may result in stormwater runoff, which may increase concentrations of toxic contaminants including, but not limited to, hormones, PCBs, heavy metals, and petroleum products in both the sediments and water column. Additionally, discharges containing nitrogenous and bacterial waste associated with wastewater treatment, industrial processes or fish hatcheries may decrease water and sediment quality as well as contribute towards eutrophication of the nearshore environment. Net pens associated with fish hatcheries and aquaculture operations may also contribute to the loss of adult habitat from shading and the introduction of disease and parasites. Because black rockfish have a preference for shallow, rocky substrates, they are especially vulnerable to habitat disturbance and loss. Overwater structures and shoreline modifications may negatively affect habitat by reducing or modifying macroalgae, kelp and eelgrass habitat. Furthermore, sediment flow could be changed by bulkheads and jetties and subsequently suffocate habitat.

4-20.8 Species Coverage Recommendation and Justification

Black rockfish should be considered an **Evaluation Species** because: 1) Although the species is not federally listed, it is listed as a Candidate Species in the state of Washington; 2) Washington DNR activities have a “medium” potential to effect black rockfish; and 3) Insufficient information is available to assess impacts and to develop conservation measures. In particular, the distribution of black rockfish during adult and juvenile life stages is lacking.

4-20.9 References

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4-21 Bocaccio

4-21.1 Species name

Sebastes paucispinis

Common Name: Bocaccio

Initial coverage recommendation: Evaluation

4-21.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not listed

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

G5

NATURAL HERITAGE PROGRAM STATE RANK

Not Ranked

4-21.3 Range

Bocaccio are found from Alaska to northern Baja California, Mexico, and are most abundant in the offshore waters of Oregon and California (Dark et al. 1983; Eschmeyer et al. 1983; Love et al. 2002).

Bocaccio have been found on rocky outcroppings in the offshore waters of Washington (Love et al. 2002) and in the coastal waters of Puget Sound from Bellingham to Tacoma (Miller and Borton 1980). Canadian assessments have shown bocaccio to be present in the Strait of Juan de Fuca and abundant along the northwest coast of Vancouver Island (COSEWIC 2002). Current distributions of bocaccio in Washington are unknown, therefore no species distribution map is presented for this species.

4-21.4 Habitat Use

ADULT

Like other rockfish, bocaccio are associated with rocky outcroppings and walls (consolidated habitat) in both coastal and inland waters. Bocaccio most commonly inhabit depths less than 200 meters, but can be found at greater depths (Dark et al. 1983). In a tagging study, Starr et al. (2002) found that bocaccio occupied waters between 10 and 170 meters. Love et al. (1990) showed larger fish to occupy deeper habitats, a trend common in other rockfish species. Bocaccio co-occur with several other species of semi-pelagic rockfish, including yellowtail and widow rockfish, and are often caught in mid-water trawls.

Starr et al. (2002) showed that half of the bocaccio tagged with implanted acoustic tags remained in the 12 kilometer² study area, which consisted of pinnacled consolidated habitat. Other species of rockfish have shown site fidelity in tagging experiments (Eisenhardt 2004), and the results from Starr et al. (2002) suggest that bocaccio display similar behavior. It is important to note that some fish in the tagging study may have moved large distances because they were absent from the area for prolonged periods (Starr et al. 2002).

Like yellowtail rockfish, bocaccio make rapid vertical migrations, which indicates they may be able to regulate air in their swim bladder (Starr et al. 2002). The reason for rapid vertical migrations is unknown, but may have to do with feeding behavior. Bocaccio are mainly piscivorous, consuming other rockfish, hake, sablefish, myctophids and other species of fish, as well as squids (Love et al. 2002).

Bocaccio are slow-growing and late-maturing, though age at sexual maturity is unclear (Love et al. 2002). Studies in California have shown 50 percent of females to reach maturity at 36 centimeters, though in Oregon the size is 54 centimeters (Love et al. 2002); Gunderson et al. (1980) found 50 percent maturity of fish off of Washington and Oregon to be 44.8 centimeters for males and 48.2 centimeters for females. Because of the difficulty in reading bocaccio otoliths, aging bocaccio and determining their age and growth, scientific understanding of age at maturity and maximum age is not complete (Love et al. 2002).

REPRODUCTION

Mating occurs once a year, generally in the fall or winter, though timing is not well known, especially for northern populations (Garrison and Miller 1982). Female bocaccio store sperm for 4 to 6 weeks while their eggs develop (Wyllie-Echeverria 1987). Like other *Sebastes* species, bocaccio are ovoviparous, producing live young. Females produce between 20,000 and 2.3 million eggs per season (Phillips 1964, in Stanley et al. 2001), though fecundity is not well studied in all geographic ranges (Garrison and Miller 1982).

Parturition occurs offshore during the winter months (Wyllie-Echeverria 1987). Moser (1967, in Garrison and Miller 1982) noted that bocaccio may mature two broods per year, a characteristic unique among rockfish. Once the first brood is released in early winter,

the second brood begins developing and is released in the spring. This behavior has not been well documented in Washington (Love et al. 2002).

LARVAE AND JUVENILES

Larvae most likely are released offshore and are found in the upper mixed zone of the ocean (Moser and Boehlert 1991). They are between 4.0 and 5.0 millimeters at parturition. Bocaccio larvae remain in the water column for several months while transitioning to pelagic juveniles, which occurs at about 30 millimeters (Garrison and Miller 1982). Larvae feed on zooplankton, diatoms and dinoflagellates, and increase zooplankton consumption with size (Love et al. 2002).

After spending several months in the neritic zone, bocaccio juveniles settle in nearshore areas in coastal and inland waters (MacCall 2002). As they grow, they tend to inhabit deeper habitats and occupy crevices and rocky holes in deeper water (Garrison and Miller 1982). Juveniles have been observed occupying areas of high relief and have also been associated with anthropogenic structures including off-shore oil platforms in southern California (Love et al. 2002).

4-21.5 Population Trends

Because of their life-history characteristics (long-lived, late-maturing, slow-growing) and high habitat fidelity as adults, bocaccio, like other rockfish, are particularly vulnerable to overfishing, with stocks that could take years to recover (Leaman 1991). The National Marine Fisheries Service declared bocaccio overfished, and a rebuilding plan was put into place in 2000 (see MacCall 2003 for current rebuilding analysis). It is likely that two distinct stocks exist: one ranging throughout southern/central California and one centered around the Queen Charlotte Islands in British Columbia (MacCall, Personal communication, March 2, 2005.).

Few data exist for the history of bocaccio in Washington, but bocaccio have been commercially important along the West Coast, especially in California, for over 100 years and have been targeted in groundfish fisheries since the 1960s. The Pacific Fishery Management Council has been managing the fishery (off the California, Oregon and Washington coasts) since 1982 (MacCall 2002); however, management actions during the 1980s and 1990s failed to slow the rapid decline in population. The cause for the decline is mostly attributable to overharvest, although poor larval survival and recruitment may also have contributed to the decline (Love et al. 2002; MacCall 2002).

By the late 1990s, it was estimated that exploitable biomass of bocaccio in the southern portion of their range was three percent of historical (pre-1960s) levels (Love et al. 2002; NOAA Fisheries 2004). In Canada, the species is undergoing review for the Species at Risk Act (Department of Fisheries and Oceans 2004) and is already designated as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2002). It is estimated that the population off the west coast of Vancouver Island declined by 95 percent between 1980 and 2000 (Department of Fisheries and Oceans 2004), though the current population (1996 to 2000) is stable (Stanley et al. 2001). Bocaccio is of little commercial importance in Canada (Stanley et al. 2001) and

Washington (MacCall, Personal communication. March 2, 2005). The status of the population in Washington is currently unknown, but it is likely that population trends similar to those in British Columbia have resulted in offshore waters (MacCall, Personal communication. March 2, 2005).

A petition to list Puget Sound bocaccio and 13 other species of rockfish under the Endangered Species Act was submitted to the National Marine Fisheries Service in 1999 (Wright 1999). Because of a lack of information regarding population structure and status for bocaccio and ten other species, they were eliminated from the review process (50 CFR 223 to 224 [1999]). In 2001, the Natural Resources Defense Council petitioned the National Marine Fisheries Service to list the southern population of bocaccio as Threatened under the Endangered species act (Natural Resources Defense Council 2001). Despite populations that were assessed at 3 percent of the unfished level, the petition was denied on the basis that the National Marine Fisheries Service had established a rebuilding plan and restricted commercial and recreational take (NOAA Fisheries 2004).

4-21.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Bocaccio inhabit offshore and nearshore neritic habitats and are associated with rocky consolidated substrate, habitats which are not at high risk of destruction or modification. Historically, the species has been taken by the commercial fishery in mid-water and bottom trawls, the latter of which disturbs soft benthic habitats. Current limits on catch have reduced fishing pressure. Despite the lack of direct impact to consolidated habitats, the species is at risk from direct harvest.

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

The National Oceanic and Atmospheric Administration (NOAA) Fisheries has declared bocaccio overfished, and a rebuilding management plan is in place (MacCall 2003). Overharvest has resulted from both commercial and recreational fisheries, especially in the southern portion of the range. Bocaccio are less abundant in Washington than in other regions (MacCall, Personal communication. March 2, 2005) and, therefore, they have not been aggressively harvested for commercial purposes.

DISEASE OR PREDATION

Bocaccio are known to harbor parasites, especially tapeworms and nematodes (Stanley et al. 2001), although these parasites are thought to be harmless (Love et al. 2002). Kent et al. (2001) documented *Ichthyophonus* infection rates of up to 50 percent in populations of Pacific rockfish. *Ichthyophonus hoferi* is a chronic disease that may allow hosts to survive for extended periods with little or not deleterious effects; however *Ichthyophonus* infections can cause significant pathological changes and mortality of the host.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Bocaccio have been heavily targeted by commercial fisheries, especially off the coast of California (Love et al. 2002). By declaring the species overfished, NOAA Fisheries triggered a rebuilding plan, which is currently in effect. However, for southern populations, this action probably occurred too late, and rebuilding will take place slowly over a protracted period. This species is not commercially important in Washington, though through Pacific Fishery Management Council actions, harvest has been reduced (MacCall, Personal communication. March 2, 2005).

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Recreational and commercial take, especially of the largest, oldest, most fecund fish, are the most significant concerns for all rockfish species (Parker et al. 2000).

4-21.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Bocaccio are found around consolidated habitats in marine waters, often at depths greater than 20 meters along the continental shelf (Stanley et al. 2001). Therefore, the overall potential for activities authorized by Washington DNR to impact to adult bocaccio is probably low. However, some nearshore activities, especially those such as overwater structures and shoreline modifications that disturb kelp and eelgrass beds, may affect juveniles because they use habitats in shallower, nearshore waters. Activities resulting in pollution, such as outfalls and runoff from roads, docks and bridges, may have negative impacts on bocaccio.

4-21.8 Species Coverage Recommendation and Justification

We recommend this species be considered an **Evaluation Species** because: 1) Bocaccio are not currently federally listed, but little is known about the population status in Washington; 2) Activities authorized by Washington DNR have a “medium” potential to impact bocaccio, with the largest potential impact to juveniles; and 3) Insufficient information is available to assess impacts and to develop conservation measures. In particular, specific information regarding the distribution of juvenile bocaccio is lacking.

4-21.9 References

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4-22 Brown Rockfish

4-22.1 Species Name

Sebastes auriculatus

Common Name: Brown rockfish

Initial coverage recommendation: Evaluation

4-22.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not listed

WASHINGTON FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Not Ranked

NATURAL HERITAGE PROGRAM STATE RANK

Not Ranked

4-22.3 Range

Brown rockfish range from northern Gulf of Alaska to southern Baja California (Stout et al. 2001; Love et al. 2002). In Washington, brown rockfish appear to be limited to Central and South Puget Sound, with the most reports of the species occurring near Seattle and Bainbridge Island (Miller and Borton 1980; Stout et al. 2001). A figure representing the distribution of brown rockfish in Washington may be found in Appendix F. The NOAA Fisheries status review (Stout et al. 2001) described two distinct population segments consisting of Puget Sound proper (the area south of Admiralty Inlet and east of Deception Pass), and the coastal waters west of Cape Flattery. The few brown rockfish reports outside of Puget Sound proper and inland of Cape Flattery were considered to represent vagrant brown rockfish from the Puget Sound proper population segment.

4-22.4 Habitat Use

ADULT

Adult brown rockfish most commonly use consolidated habitats in nearshore and offshore ecosystems in inland and coastal waters. While they prefer consolidated, low relief areas in shallow water bays with kelp, they have also been found in unconsolidated habitats (Matthews 1990b; Stout et al. 2001). The depth range of the brown rockfish is surface to 128 meters, and they are most common below 6 meters (Stout et al. 2001). In Puget Sound proper, the highest population densities were reported on natural reefs and rock piles in water less than 30 meters (Matthews 1990b).

Adults are solitary or occur in small aggregations, and are often associated with quillback rockfish (*Sebastes maliger*). They have a small home range, 30 square meters on Puget Sound artificial reefs to 1,500 square meters on natural low relief reefs, and exhibit strong home range fidelity that is not affected by season (Matthews 1990a, b).

Adults feed primarily near the bottom. Prey includes small fish, shrimp, polychaetes and isopods (Washington et al. 1978; Hueckel and Buckley 1987; Matthews 1987; Stein and Hassler 1989).

REPRODUCTION

In Puget Sound proper, 50 percent of male and female brown rockfish are sexually mature at 4 to 5 years old and 23 to 25 centimeters total length; with all individuals maturing by year 7 (Matthews 1987; Stout et al. 2001). Brown rockfish can reach 56 centimeters total length (Hart 1973) and have a life span of approximately 34 years (Love et al. 2002). The mortality rate for brown rockfish from central Puget Sound proper has been reported to be 0.274 (Gowan 1983).

Brown rockfish mate in March and April (Stein and Hassler 1989), have internal fertilization, and retain embryos until larval release (Boehlert and Yoklavich 1984). In Puget Sound proper, ova develop during winter, with females in Washington probably giving birth annually from May through July (Stout et al. 2001).

LARVAE AND JUVENILES

Brown rockfish are 5 to 6 millimeters in length at birth and are free floating, preying upon zooplankton (Stout et al. 2001). Larvae and juveniles use the open water habitat in the nearshore ecosystem of inland and coastal waters, as well as estuaries for nursery grounds (Stein and Hassler 1989; Stout et al. 2001).

Juvenile brown rockfish settle into shallow, vegetated habitats such as low-relief natural and artificial reefs and beds of kelp or eelgrass (West et al. 1994) at 18 to 25 millimeters total length, preferring shallower water than adults (Love 1996). After settling, juveniles feed on amphipods, copepods, polychaete worms, shrimp and small fish (Matthews 1987; Stein and Hassler 1989).

Predators on juveniles and adults include lingcod (*Ophiodon elongatus*), cabezon (*Scorpaenichthys marmoratus*), salmon (*Onchorynchus* spp.), river otters (*Lutra*

canadensis), sea lions (*Zalophus californianus*), harbor seals (*Phoca vitulina*), great blue heron (*Ardea herodias*), cormorants (*Phalacrocorax* spp.) and various other marine bird species (Fresh et al. 1981; Jones 2000; Eisenhardt 2001).

4-22.5 Population Trends

In Puget Sound proper, scuba surveys showed brown rockfish populations increasing by a factor of approximately 6 between 1987 and 1995 (Matthews 1990a; Stout et al. 2001). However, annual trawl surveys during the same period suggested a decline from 761,000 to approximately 30,000 individuals (Stout et al. 2001). Data from recreational fisheries for the years 1996 to 1999 indicated variable recreational catches ranging from 800 to 6,000 with the highest catches in 1997 (6,000 fish) and 1999 (4,000), and the lowest catches in 1998 (800) and 1996 (1,800) (Stout et al. 2001).

Brown rockfish are rare in coastal ecosystems, and no data was available for analysis by the NOAA Fisheries status review (Stout et al 2001).

4-22.6 Assessment of Threats Warranting ESA Protection

The risks to the survival of brown rockfish were listed by West (1997) as “anthropogenic stressors and natural limiting factors,” and include “over-harvesting, loss or degradation of habitat, predation by pinnipeds and fish, and pollution-related adverse effects.”

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Habitat for juvenile rockfish could be affected through shoreline development. Sediment flow can be affected by bulkheads or jetties and change sediment characteristics in shallow water where benthic juvenile brown rockfish concentrate. Loss of eelgrass or kelp through dredging or filling may negatively affect juvenile and adult habitat (Palsson et al. 1998).

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Brown rockfish have comprised up to 31 percent of the recreation harvest in Puget Sound proper (Gowan 1983) and like most rockfish are vulnerable to commercial and recreational over-harvest (West 1997; Stout et al. 2001). There are no known scientific or educational uses for brown rockfish.

DISEASE OR PREDATION

While disease is not known to be a significant threat to this species, predation from sea lions (*Zalophus californianus*) and harbor seals (*Phoca vitulina*) may be a factor in decreasing population trends. Due to their protection under the Marine Mammal

Protection Act of 1972 pinniped populations have increased and may be placing additional strain on brown rockfish populations.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

While Washington Fish and Wildlife has prohibited the direct harvest of rockfishes in Puget Sound, rockfish continue to be at risk from bycatch for lingcod and salmon fisheries.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Additional factors affecting brown rockfish include possible sub-lethal affects from bioaccumulation and concentration of chemical contaminants (West 1997; West and O'Neill 1998); and the possible feminization of male rockfish as a result of human estrogen/progesterone in the water (West 2004). While some studies have suggested decreases in reproductive success and survival of young rockfish as a result of ocean climate fluctuations such as El Nino and La Nina Southern Oscillation and Pacific Decadal Oscillation (Partnership for Interdisciplinary Studies of Coastal Oceans 2004), the magnitude of this variable in Washington is currently unknown.

4-22.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Brown rockfish are likely to be affected by activities authorized by Washington DNR within marine nearshore environments. Roadways, bridges, and docks may result in stormwater runoff which may increase concentrations of contaminants such as hormones, PCBs, heavy metals and petroleum products in both the sediments and water column. Additionally, discharges containing nitrogenous and bacterial waste associated with wastewater treatment, industrial processes or fish hatcheries may decrease water and sediment quality as well as contribute to eutrophication of the nearshore environment. Net pens associated with fish hatcheries and aquaculture operations may also contribute to the loss of adult habitat from shading and the introduction of disease and parasites. Since brown rockfish have a relatively small home range and a preference for shallow, low relief reefs, and artificial structures (e.g., piers), they are especially vulnerable to habitat disturbance and loss. Overwater structures and shoreline modifications may negatively affect habitat by reducing or modifying macroalgae, kelp, and eelgrass habitat. Dredging or disposal of dredged materials has the potential to cover brown rockfish habitat. Furthermore, sediment flow could be changed by bulkheads and jetties and subsequently suffocate habitat.

4-22.8 Species Coverage Recommendation and Justification

It is recommended that brown rockfish be addressed as an **Evaluation Species** for the following reasons: 1) Although the species is not federally listed as Threatened,

Endangered or as a Species of Concern, it is listed as a Candidate Species in Washington State and the Puget Sound distinct population segment is considered vulnerable by the International Union for the Conservation of Nature; 2) Activities authorized by Washington DNR have a "medium" potential to affect brown rockfish; and 3) Sufficient information is available to assess impacts and to develop conservation measures.

4-22.9 References

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4-23 Canary Rockfish

4-23.1 Species Name

Sebastes pinniger

Common Name: Canary rockfish

Initial coverage recommendation: Evaluation

4-23.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS (NOAA FISHERIES)

Not listed

National Oceanic and Atmospheric Administration (NOAA) Fisheries declared canary rockfish overfished in 2000

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK:

Not Ranked

NATURAL HERITAGE PROGRAM STATE RANK:

Not Ranked

4-23.3 Range

Canary rockfish are distributed from the Gulf of Alaska to northern Baja California, Mexico, but are thought to be most abundant from southeastern Alaska to northern California (Hart 1973). They live close to the ocean bottom near the edge of the continental shelf, from 40 to 450 meters deep (Methot and Piner 2001). In Washington, while canary rockfish are found offshore along the outer coast, and were once common in Puget Sound (Garrison and Miller 1982), their current distribution is unknown. Information regarding the geographic distribution of canary rockfish for all life stages is incomplete, therefore no species distribution map is presented for this species.

4-23.4 Habitat Use

ADULT

Adult canary rockfish are benthopelagic, forming loose schools in the water column over rocky habitat, similar to widow and yellowtail rockfish. They have been observed over cobble, mud and sand habitats as well, especially in the interface between those habitats and rock structure (Love et al. 2002). Canary rockfish appear to inhabit deeper waters as they age (Methot and Piner 2001) and are found in shallower waters in the northern part of their range (Love et al. 2002). Canaries co-occur with yellowtail, black, widow, silvergray and other species of rockfish (Tagart 1987).

Adult canary rockfish feed on both water-column and benthic prey items, with euphausiids and fish (myctophids, anchovies, flatfish and juvenile rockfish) common prey (Love et al. 2002).

Canary rockfish can live to more than 80 years and reach a maximum size of more than 70 centimeters long (Wilkins et al. 1998). Maturity schedules vary within west coast studies, but off the Washington and Oregon coasts, it is believed that females reach sexual maturity at about 8 years of age and about 50 centimeters in length (Methot and Piner 2001), whereas males become sexually mature at about 7 years of age and 40 centimeters in length (Methot and Piner 2001; Love et al. 2002). Little is known about age and growth of canary rockfish in Puget Sound relative to offshore populations, although for many species of rockfish, maturity schedules and growth rates vary by geographic location (Matarese et al. 1989).

REPRODUCTION

Mating occurs from September to March, with the peak being in December and January off the Washington coast (Methot and Piner 2001). Females produce from 250,000 to over 2 million eggs per year (Love et al. 2002), and egg production is correlated with fish size (Gunderson et al. 1980). Like other species of rockfish, canary rockfish are ovoviparous, producing live young.

Parturition occurs from January to March in north Pacific waters (Westrheim 1975), but timing is not well known for canary rockfish in Puget Sound or on the Washington coast.

LARVAE AND JUVENILES

Canary rockfish larvae are generally less than 4 mm in length at parturition (Love et al. 2002) and are found in the upper portion of the water column (Methot and Piner 2001), generally in the winter and spring (Matarese et al. 1989). Because of the difficulty in identifying larval rockfish, little is known about the ecology of individual species (Matarese et al. 1989).

Juvenile canary rockfish are thought to remain in the plankton for up to 4 months or until about 4 centimeters in length (Love et al. 2002). When in their pelagic phase, juveniles eat zooplankton and their eggs, specifically, copepods and euphausiids (Love et al. 2002).

Once they settle to benthic habitats, they are often associated with kelp beds or other nearshore areas with relief and structure (Sampson 1996). They can be found in water that is shallow (10 to 20 meters) and may be in small schools. They have been observed schooling over rocky reefs and the adjacent unconsolidated sediment, forming small groups in cracks and crevices (Love et al. 2002). As they grow, they move to deeper habitats (Boehlert 1980).

4-23.5 Population Trends

Canary rockfish have been declared overfished by NOAA Fisheries, and a rebuilding management plan is currently in place (Pacific Fishery Management Council 2003). The current biomass is estimated at approximately 8 percent of the unfished spawning biomass (Methot and Piner 2001). In British Columbia, the stocks are considered close to maximum exploitation, though surveys have been imperfect at assessing populations (Department of Fisheries and Oceans 1999).

Trawl harvest for canary rockfish began in the 1940s but gathered momentum in the late 1970s and 1980s (Williams and Adams 2001). Since then, canary rockfish have experienced population declines as a result of being targeted by recreational and commercial fisheries. The decline in population wasn't recognized by managers until the mid-1990s, at which point the acceptable catch was lowered (Methot and Piner 2001). Today, the commercial effort has been cut dramatically, and the majority of the catch is either from bycatch or other incidental take (Pacific Fishery Management Council 2003). This reduction has meant lesser pressure on other fish species associated with canary rockfish, such as yellowtail rockfish.

Canaries were sought by the recreational fishery off the Washington and Oregon coast, but are now a prohibited catch in both states. Few data exist for population trends in Puget Sound. Washington Department of Fish and Wildlife plans to conduct population assessments in Puget Sound in the near future.

4-23.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Canary rockfish inhabit offshore consolidated habitats, which are not at high risk of destruction or modification. They are taken by the commercial fishery in mid-water trawls, which have minimal impacts on benthic habitats. Despite the lack of direct impact to consolidated habitats, the species is at risk from direct harvest.

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

NOAA Fisheries has declared canary rockfish to be overfished. Commercial harvest quotas have been reduced significantly in the last decade, and a rebuilding plan is in place (Pacific Fishery Management Council 2003). The recreational fisheries in Washington and Oregon have restricted the retention of incidentally caught canary rockfish, because of their declining populations. The harvest of larger, more fecund fish has led to poor recruitment in some years, especially given unfavorable oceanic conditions (Parker et al. 2000).

DISEASE OR PREDATION

While disease is not known to be a significant threat to this species, predation from sea lions (*Zalophus californianus*) and harbor seals (*Phoca vitulina*) may be a factor in decreasing population trends. Due to their protection under the Marine Mammal Protection Act of 1972 pinniped populations have increased and may be placing additional strain on canary rockfish populations.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Stocks of canary rockfish were targeted heavily for commercial harvest starting in the 1970s. By the 1990s, managers realized that the population had decreased significantly and began lowering allowable catch (Methot and Piner 2001). By declaring the species overfished, NOAA Fisheries triggered a rebuilding plan, which is currently in effect (Pacific Fishery Management Council 2003). The Puget Sound Groundfish Management Plan (Palsson et al. 1998) stresses the management of the resource in a conservative manner to prevent overharvest, but rockfish stocks in Puget Sound have declined, largely prior to adoption of the most recent plan.

Additionally, little is known about the specific ecology of individual rockfish species. Little is known about larval and juvenile ecology, food habits, or how oceanic conditions impact recruitment (Harvey 2005). Further study is needed to adequately manage rockfish species.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Recreational and commercial take, especially of the largest, oldest, and thus, most fecund fish are the most significant concerns for rockfish (Parker et al. 2000).

4-23.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Canary rockfish are generally found offshore at the edge of the continental shelf, so the potential effects from activities authorized by Washington DNR are probably low. However, while the overall impacts from shore-based activities (such as overwater structures and piers) are thought to be minimal, within Puget Sound pollution from

outfalls and runoff from roads, docks and bridges, may have negative impacts on canary rockfish.

4-23.8 Species Coverage Recommendation and Justification

Canary rockfish should be listed as an **Evaluation Species** because: 1) While the species is not federally listed, it is considered overfished by NOAA Fisheries and the Washington Department of Fish and Wildlife lists the species a Candidate Species, prohibiting recreational take because of low population levels; 2) Washington DNR activities have a “low” potential to canary rockfish; and 3) Insufficient information is available to assess impacts and to develop conservation measures. In particular, specific information regarding the distribution of adult and juvenile canary rockfish is lacking.

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4-24 Copper Rockfish

4-24.1 Species Name

Sebastes caurinus

Common Name: Copper rockfish

Initial coverage recommendation: Evaluation

4-24.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not Listed

WASHINGTON FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Not Ranked

NATURAL HERITAGE PROGRAM STATE RANK

Not Ranked

4-24.3 Range

Copper rockfish range from the Gulf of Alaska to central Baja California (Miller and Lea 1972). This species is widely distributed in Puget Sound and Washington's coastal waters with the exception of the Southeast Georgia Strait area (Miller and Borton 1980). A figure representing the distribution of copper rockfish in Washington may be found in Appendix F.

The NOAA Fisheries status review delineated three distinct population segments within Washington's waters - Northern Puget Sound (San Juan Islands and Straits of Juan de Fuca), Puget Sound Proper, and Outer Coast (Cape Flattery west) (Stout et al. 2001). The North Puget Sound population segment includes not only Washington waters but also the Canadian Gulf Islands and the Strait of Georgia (Stout et al. 2001). The boundaries of

the Outer Coast population segment are also broad and ill defined, including areas south into California and north into Alaska. Only the Puget Sound population segment was clearly defined as that area labeled “Puget Sound proper,” defined as the marine waters south of Admiralty Inlet and east of Deception Pass.

4-24.4 Habitat Use

ADULTS

Adult copper rockfish prefer consolidated habitats of nearshore and upper offshore ecosystems in coastal and inland waters. Their depth range is between 1 and 23 meters in high relief rocky reefs and low relief areas when kelp cover is present (Matthews 1990a). Adults are solitary or occur in small aggregations with a small home range of 10 to 4,000 square meters (Mathews and Barker 1983; Matthews 1990b). During the winter this species may migrate to deeper water or retreat into crevasses (Richards 1987).

Copper rockfish feed primarily near the bottom during mid-day. Prey includes brachyuran crabs, gammarid amphipods, euphausiids, calanoid copepods, and fish such as shiner surfperch (*Cymatogaster aggregata*), Pacific herring (*Clupea pallasii*) cottids, kelp greenling (*Hexagrammos decagrammus*) and spiny dogfish (*Squalus acanthias*) (Patten 1973; Wingert 1979; Hueckel and Stayton 1982; Murie 1995). Predators may include lingcod (*Ophiodon elongatus*), cabezon (*Scorpaenichthys marmoratus*), salmon (*Onchorynchus* spp.), river otters (*Lutra canadensis*), sea lions (*Zalophus californianus*), harbor seals (*Phoca vitulina*), great blue heron (*Ardea herodias*), cormorants (*Phalacrocorax* spp.) and various other marine bird species.

REPRODUCTION

All species of rockfish have internal fertilization and retain the eggs until larval release (Boehlert and Yoklavich 1984). Mating behavior of copper rockfish has been observed during October in mid-water in San Juan Channel (Eisenhardt, Personal communication. September 27, 2003). Both sexes mature around the same time, at 4 to 6 years of age (Richards and Cass 1985; Stein and Hassler 1989) with parturition occurring in April, May and June in Washington (DeLacy et al. 1964; Moulton 1977; Washington et al. 1978). Copper rockfish can reach 55 years old (Matthews 1987) and 57 centimeters total length (Stein and Hassler 1989).

LARVAE AND JUVENILES

Larval fish are extruded into the nearshore inland and coastal neritic zones and associate with shallow water habitats including algae attached to overwater structures, shallow consolidated reefs and eelgrass meadows (Doty et al. 1995). They remain off the bottom in these habitats until they reach 20 to 45 millimeters total length (Buckley 1997; Love et al. 2002), preying on zooplankton (calanoid copepods, gammarid amphipods, cyprid larvae), polychaetes and larval fish (Murie 1995; Hueckel and Stayton 1982).

At 50 to 90 millimeters total length, juveniles settle into benthic habitats on consolidated high-relief rocky reefs, and/or in kelp or eelgrass beds at the unconsolidated and consolidated rock interface in water no deeper than 18 meters (Matthews 1988; Matthews

1990a; West et al. 1994; Doty et al. 1995; Buckley 1997). Movement from off bottom to benthic habitats occurs from July to October.

The juveniles are crepuscular feeders, concentrating feeding activity at dawn and dusk on small fish and crustaceans (Patten 1973; Hueckel and Stayton 1982; Hueckel and Buckley 1987).

4-24.5 Population Trends

The NOAA Fisheries status review (Stout et al. 2001) found differing population trends within the three population segments defined in Washington. Within the Outer Coast population segment, data for recreational catches within three miles of the Pacific Coast for 1993 to 1999 suggest a gradual decline in catch in 1995, a modest increase in 1996 and a decrease in 1997. Since 1997, a gradual increase was observed in 1999 (Stout et al. 2001). Length-frequency patterns for these years were similar.

In North Puget Sound, a number of different methods each provided descriptions of population trends (Stout et al. 2001). Trawl surveys indicate a decline from 72,000 fish in 1987 to 17,000 in 1995. Data from scuba diving surveys show a lower density of copper rockfish at a fished site in contrast to an unfished location. The catch per trip of all rockfish species (data for copper rockfish were not separated) in the recreational fishery fluctuated between 0.6 and 1.0 during 1980 to 1999, with no apparent trend after a decline from higher levels in the late-1970s. The length frequency data in this fishery show a decline prior to 1985 in the average length due to a reduction in the fraction of fish greater than 45 centimeters (Stout et al. 2002).

In the Puget Sound proper population segment, trawl, scuba, and video surveys indicate a substantial decline in the numbers and biomass of copper rockfish during 1987 to 1997. For instance, the numbers in scuba surveys declined from 40 to 4.88 copper rockfish per 270 square meters. In addition, an analysis of fish taken in the recreational fishery indicated that egg production also declined substantially. In summary, the decline in population in the Puget Sound proper population segment appears to be 70 to 80 percent over 25 years (Stout et al. 2001).

4-24.6 Assessment of Threats Warranting ESA Protection

The risks to the survival of the copper rockfish were listed by West (1997) as “anthropogenic stressors and natural limiting factors,” and include “overharvesting, loss or degradation of habitat, predation by pinnipeds and fish, and pollution-related adverse effects.”

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Habitat for juvenile rockfish could be affected through shoreline development. Adult habitat does not appear to be limiting at this time because unoccupied habitat is apparently present in Puget Sound (Stout et al. 2002).

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Copper rockfish are vulnerable to over harvest by recreational fisheries in all population segments. West's (1997) presentation of risk factors for copper rockfish in greater Puget Sound points to overharvest as the probable major factor contributing to the decline of these fish. This conclusion was further supported by the findings of the NOAA Fisheries status review (Stout et al. 2001). Late maturing, long-lived species such as rockfish are slow to rebuild depleted populations making them particularly sensitive to overfishing. There are no known scientific or educational uses for copper rockfish.

DISEASE OR PREDATION

While disease is not known to be a significant threat to this species, predation from sea lions (*Zalophus californianus*) and harbor seals (*Phoca vitulina*) may be a factor in decreasing population trends. Due to their protection under the Marine Mammal Protection Act of 1972 pinniped populations have increased and may be placing additional strain on copper rockfish populations.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

The current Washington Department of Fish and Wildlife management strategy is to eliminate targeted harvest of rockfishes in Puget Sound. These rules became effective in 2004 and will help reduce fishing effort on rockfishes. However, the limits may be inadequate protection due to the fact that rockfish constitute a large percentage of the bycatch for lingcod and salmon fisheries

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Additional factors affecting copper rockfish include possible sub-lethal affects from bioaccumulation and concentration of chemical contaminants (West 1997; West and O'Neill 1998); and the possible feminization of male rockfish as a result of human estrogen/progesterone in the water (West 2004). While some studies have suggested decreases in reproductive success and survival of young rockfish as a result of ocean climate fluctuations such as El Nino and La Nina Southern Oscillation and Pacific Decadal Oscillation (Partnership for Interdisciplinary Studies of Coastal Oceans 2004), the magnitude of this variable in Washington is currently unknown.

4-24.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Copper rockfish are likely to be affected by activities authorized by Washington DNR within marine nearshore environments. Roadways, bridges, and docks may result in stormwater runoff which may increase concentrations of toxic contaminants including but not limited to hormones, PCBs, heavy metals and petroleum products in both the sediments and water column. Additionally, discharges containing nitrogenous and bacterial waste associated with wastewater treatment, industrial processes or fish hatcheries may decrease water and sediment quality as well as contribute towards eutrophication of the nearshore environment. Net pens associated with fish hatcheries and aquaculture operations may also contribute to the loss of adult habitat through shading and the introduction of disease and parasites. Since copper rockfish have a relatively small home range and a preference for shallow, low relief reefs and artificial structures (e.g., piers), they are especially vulnerable to habitat disturbance and loss. Overwater structures and shoreline modifications may negatively affect habitat by reducing or modifying macroalgae, kelp, and eelgrass habitat. Dredging or disposal of dredged materials has the potential to cover brown rockfish habitat. Furthermore, sediment flow could be changed by bulkheads and jetties and subsequently suffocate habitat.

4-24.8 Species Coverage Recommendation and Justification

It is recommended that copper rockfish be addressed as an **Evaluation Species** for the following reasons: 1) Although the species is not federally listed, copper rockfish are listed as a Candidate Species in Washington State and the Puget Sound distinct population segment is considered vulnerable by the International Union for the Conservation of Nature; 2) Activities authorized by Washington DNR have a "medium" potential to affect copper rockfish; and 3) Sufficient information is available to assess impacts and to develop conservation measures.

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4-25 *Sebastes* Complex

4-25.1 Species Name

For the purposes of this paper, the following four rockfish species are considered as a “complex”: Greenstriped rockfish (*Sebastes elongatus*); China rockfish (*Sebastes nebulosus*); Tiger rockfish (*Sebastes nigrocinctus*); and Redstripe rockfish (*Sebastes proriger*). These species share common life histories traits and occupy similar habitats, allowing them to be treated together.

Common Names: Greenstriped rockfish; China rockfish; Tiger rockfish; Redstripe rockfish

Initial coverage recommendation for all species: Evaluation

4-25.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Species	Status
Greenstriped rockfish	Not listed
China rockfish	Not listed
Tiger rockfish	Not listed
Redstripe rockfish	Not listed

WASHINGTON FISH AND WILDLIFE STATUS

Species	Status
Greenstriped rockfish	Candidate
China rockfish	Candidate
Tiger rockfish	Candidate
Redstripe rockfish	Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Species	Status
Greenstriped rockfish	G5
China rockfish	Not ranked
Tiger rockfish	G4
Redstripe rockfish	G5

NATURAL HERITAGE PROGRAM STATE RANK

Species	Status
Greenstriped rockfish	S4
China rockfish	Not ranked
Tiger rockfish	S2
Redstripe rockfish	S3S4

4-25.3 Range

All four species in this complex range from Alaska, Gulf of Alaska or the Aleutian Islands to southern California (Love et al. 2002). The individual species have the following distributions in Washington:

- Greenstriped rockfish - coastal waters, the Strait of Juan de Fuca, Central and South Puget Sound, and Hood Canal (DeLacy et al. 1972; Gardner 1981).
- China rockfish - Strait of Juan de Fuca, San Juan Islands (DeLacy et al. 1972).
- Tiger rockfish - San Juan Islands, Central Puget Sound (DeLacy et al. 1972).
- Redstriped rockfish - San Juan Islands, North Puget Sound (eastern San Juan Islands, Bellingham), Possession Sound (Everett), Central Puget Sound, Hood Canal (DeLacy et al. 1972; Gardner 1981).

It is likely that all four species use coastal offshore habitats as indicated by the fact that all except tiger rockfish, were reported using coastal waters in British Columbia by Hart (1973). Information regarding the geographic distribution of these rockfish for all life stages is incomplete, therefore no species distribution map is presented for these species.

4-25.4 Habitat Use

ADULT

- Adult fish in this complex are generally benthic but may use the water column for feeding. Although little is known of the ecology and behavior of these four species in Washington, their habitat preferences have been documented:
Greenstriped rockfish - Offshore and deep offshore ecosystem, primarily coastal waters, between 100 to 250 meters in consolidated and unconsolidated rocky habitats (Love et al. 2002). Greenstriped rockfish are benthic resting on the bottom (Love et al. 2002). Adults of this species may reach 54 years of age and a maximum-recorded size of 43 centimeters. Off the Washington coast, 50 percent of male greenstriped rockfish reach sexual maturity at age 10 (23 centimeters) and 50 percent of females reach sexual maturity at age 7 (21 centimeters) (Love et al. 2002).
- China rockfish - Nearshore and offshore ecosystems, primarily coastal waters, between 3 and 128 meters in consolidated habitats including high-relief outcrops

with caves and crevices, rugged bottoms, and boulder fields with high wave or current energy (Love et al. 2002). Male and female China rockfish reach sexual maturity at approximately 30 centimeters in length and at 6 years of age. The maximum-recorded age for China rockfish is 79 years with a maximum size of 45 centimeters (Love et al. 2002).

- Tiger rockfish - Nearshore and offshore and deep offshore ecosystems, inland waters, between 18 to 298 meters in consolidated habitats in the form of rock outcrops with caves and crevices (Love et al. 2002). This species is benthic and uses crevices and shallow caves. On average, female tiger rockfish reach sexual maturity between 28 and 47 centimeters, while males mature between 36 to 49 centimeters. Tigers are a long-lived species and are known to reach at least 116 years in age (Oregon Department of Fish and Wildlife 2002), with a maximum size recorded of 61 centimeters.
- Redstriped rockfish - Offshore ecosystem, primarily coastal waters, between 150 to 275 meters in consolidated habitats in the form of rugged solid rock bottoms with high relief (Love et al. 2002). The species is usually benthic but may be parademersal forming dense near-bottom schools by day and dispersing at night (Love et al. 2002). Fifty percent of the redstripe rockfish off the Washington coast reach sexual maturity at seven years of age (Love et al. 2002), with males approximately 26 centimeters in length and females 28 centimeters. Redstripe rockfish reach a maximum size of 51 centimeters and a maximum age of 55 years (Love et al. 2002).

REPRODUCTION

Similarly to other rockfish, this complex, has internal fertilization and is ovoviviparous, producing live young. Eggs develop internally and hatch several days before they are extruded (parturition) (Love et al. 2002). Some species are multiple brooders, releasing young two or more times per year.

- Greenstriped rockfish release larvae that are approximately 5 millimeters long during late spring and early summer off Oregon, Washington and British Columbia (Hart 1973).
- China and tiger rockfish undergo parturition from May to June off the Oregon coast.
- Redstripe rockfish release their larvae in Puget Sound during July (Kendall and Lenarz 1986; Garrison and Miller 1982), with the larvae 3 to 7 millimeters upon release.

LARVAE AND JUVENILES

Little data are available on predators of these fish, however they are likely vulnerable to predation by larger fish, birds and marine mammals with younger, smaller individuals particularly susceptible (Oregon Department of Fish and Wildlife 2002). Love et al. (2002) reported that both redstripe and greenstriped rockfish have been found in the stomachs of Chinook salmon (*Oncorhynchus tshawytscha*).

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- Greenstriped rockfish - Larvae undergo a planktonic period lasting one to two months. While drifting, these fish mostly feed on smaller plankton such as copepods and are likely preyed upon by siphonophores and chaetognaths (Oregon Department of Fish and Wildlife 2002). In Monterey Bay, greenstriped rockfish larvae settle at 3 centimeters in length in water deeper than 40 meters over soft bottoms. Newly settled fish have a growth rate of 0.17 millimeters per day, with the juveniles moving to deeper water as they mature. Juvenile prey items include krill, fishes, shrimp, calanoid copepods, squid, and gammarid amphipods (Love et al. 2002).
 - China rockfish - The planktonic period for this species lasts one to two months, with the larvae feeding on smaller plankton such as copepods and preyed upon by siphonophores and chaetognaths (Oregon Department of Fish and Wildlife 2002). Settlement occurs when larvae reach 6 centimeters (Love et al. 2002) in depths between 30 to 89 meters (Love et al. 1990). In southeast Alaska, Rosenthal et al. (1982) observed juvenile China rockfish in shallow subtidal water during summer and early fall. Juveniles likely feed on benthic organisms such as echinoderms, crabs, shrimp, chitons and small fish (Rosenthal 1988).
 - Tiger rockfish - Similarly to China rockfish, tiger rockfish larvae undergo a planktonic period for one to two months. While drifting, these larvae feed on smaller plankton such as copepods and are likely prey for siphonophores and chaetognaths (Oregon Department of Fish and Wildlife 2002). Larvae in Puget Sound and off the Washington and British Columbia coast were reported by Love et al. (2002) as associating with drifting vegetation. In Alaska, Love et al. (2002) reported they settle in waters as shallow as 9.1 meters. Little additional data are available for tiger rockfish juveniles.
 - Redstripe rockfish - Larvae feed on all stages of copepods and euphausiids (Kendall and Lenarz 1986) and are likely a food source for planktonic predators such as siphonophores and chaetognaths (Oregon Department of Fish and Wildlife 2002). Juvenile redstripe rockfish exhibit a pelagic to semi-demersal movement pattern (Garrison and Miller 1982) and utilize both marine and estuarine habitat feeding on all stages of copepods and euphausiids (Kendall and Lenarz 1986).

4-25.5 Population Trends

There are little data on population trends for this complex of rockfish. However, population trends for many other species of rockfish show evidence of declining abundance due to overharvest as either the target species or as by-catch (Wright 1999; Love et al. 2002). Wright (1999) stated that the entire genus (*Sebastes*) is at risk because the life history characteristics (slow growth and late maturity) make them extremely vulnerable to over fishing.

4-25.6 Assessment of Threats Warranting ESA Protection

Wright's (1999) petition to list 13 species of rockfish in Puget Sound (including this complex) discusses several activities that threaten either the rockfish or their essential habitat. These threats are listed below.

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

With the exception of china rockfish, this complex generally inhabits deeper nearshore and offshore-consolidated habitats and are therefore not at high risk for the destruction or modification of habitat.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

There are no known commercial fisheries that target this complex of rockfish and Washington Fish and Wildlife has strict limits for recreational take (Palsson et al. 1997). Similarly to all rockfish, this complex is at risk due to recreational fishing pressure on the largest and oldest fish and a resulting depletion in reproductive populations. There are no known scientific or educational uses for this complex of rockfish.

DISEASE OR PREDATION

While disease is not known to be a significant threat to these species, predation from sea lions (*Zalophus californianus*) and harbor seals (*Phoca vitulina*) may be a factor in decreasing population trends. Due to their protection under the Marine Mammal Protection Act of 1972 pinniped populations have increased and may be placing additional strain on rockfish populations.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Washington Fish and Wildlife manages all of these species and imposes strict catch limits (Palsson et al. 1997). However, the limits may be inadequate protection due to the fact that rockfish constitute a large percentage of the bycatch for lingcod and salmon fisheries.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Additional factors affecting this complex rockfish include possible sub-lethal affects from bioaccumulation and concentration of chemical contaminants (West 1997; West and O'Neill 1998); and the possible feminization of male rockfish as a result of human estrogen/progesterone in the water (West 2004). While some studies have suggested decreases in reproductive success and survival of young rockfish as a result of ocean climate fluctuations such as El Nino and La Nina Southern Oscillation and Pacific Decadal Oscillation (Partnership for Interdisciplinary Studies of Coastal Oceans 2004), the magnitude of this variable in Washington is currently unknown.

4-25.7 Assessment of Potential Effects from Washington DNR Authorized Activities

The four species of rockfish that constitute this complex are likely to be affected by activities authorized by Washington DNR within marine nearshore environments. Roadways, bridges, and docks may result in stormwater runoff which may increase concentrations of toxic contaminants including but not limited to hormones, PCBs, heavy metals and petroleum products in both the sediments and water column. Additionally, discharges containing nitrogenous and bacterial waste associated with wastewater treatment, industrial processes or fish hatcheries may decrease water and sediment quality as well as contribute towards eutrophication of the nearshore environment. Net pens associated with fish hatcheries and aquaculture operations may also contribute to the loss of adult habitat from shading and the introduction of disease and parasites. Overwater structures and shoreline modifications may negatively affect habitat by reducing or modifying macroalgae, kelp, and eelgrass habitat. Dredging or disposal of dredged materials has the potential to cover rockfish habitat. Furthermore, sediment flow could be changed by bulkheads and jetties and subsequently suffocate habitat. Deep-water activities in the offshore ecosystem such as utility corridors may also disrupt and affect adult habitat.

4-25.8 Species Coverage Recommendation and Justification

It is recommended that this complex of rockfish be addressed as **Evaluation species** for the following reasons: 1) Although none of the species are federally listed as Threatened, Endangered or as a Species of Concern, they are all listed as Candidate Species in Washington State; 2) Activities authorized by Washington DNR have a "medium" potential to affect these rockfish; and 3) Insufficient information is available to assess impacts and to develop conservation measures. In particular, specific information regarding the distribution of these rockfish at adult and juvenile life stages is lacking.

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4-26 Quillback Rockfish

4-26.1 Species Name

Sebastes maliger

Common Name: Quillback rockfish

Initial coverage recommendation: Evaluation

4-26.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not Listed

WASHINGTON FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Not Ranked

NATURAL HERITAGE PROGRAM STATE RANK

Not Ranked

4-26.3 Range

Quillback rockfish range from Kenai Peninsula in the Gulf of Alaska to southern California (Stout et al. 2001; Love et al. 2002). In Washington, they are common in the San Juan Islands and Puget Sound proper (the area south of Admiralty Inlet and east of Deception Pass) (Miller and Borton 1980, Stout et al. 2001) (Appendix F). Washington State Department of Fish and Wildlife (Washington Fish and Wildlife) trawl surveys found quillback rockfish in the Strait of Juan de Fuca, the Washington portion of the Strait of Georgia, and in the Gulf of Bellingham (Stout et al. 2001). In addition, reports have confirmed the occurrence of quillback rockfish in non-estuarine coastal waters of Washington, with Gardner (1981) indicating that quillback rockfish were not found in Grays Harbor, Willapa Bay or the Columbia River estuary.

The NOAA Fisheries status review (Stout et al. 2001) proposed 3 distinct population segments for Washington - the coastal waters west of Cape Flattery, Puget Sound proper and a northern Puget Sound population that includes the San Juan Islands, Strait of Georgia, and a portion of the coast. It should be noted that the NOAA Fisheries status review did not cite any data or sources of information detailing the occurrence of quillback rockfish off the Washington coast.

4-26.4 Habitat Use

ADULTS

In Washington, adult quillback rockfish prefer consolidated habitats in the shallow subtidal nearshore and upper offshore ecosystems of inland waters (Stout et al. 2001). While maximum depths are 275 meters (Stout et al. 2001, Love et al. 2002), in greater Puget Sound the highest densities are on shallow reefs less than 30 meters deep (Matthews 1990a; Stout et al. 2001).

Adults are solitary, bottom oriented fish with a small home range (10 to 100 square meters) (Matthews 1990a, b) that prefer consolidated, high relief rocky reefs with kelp cover. However, these rockfish will also use low relief reefs and unconsolidated habitats when ribbon kelp (*Laminaria* sp.) is present (Matthews 1990a; Stout et al. 2001; Love et al. 2002) and may migrate to deeper water during the winter (Matthews 1990a).

Quillback rockfish can reach 61 centimeters total length and live to be 95 years old (Love et al 2002). Both sexes mature around the same time, between 5 and 13 years of age and 29 centimeters total length (Matthews 1987, Stout et al. 2001).

Adult quillback rockfish primarily feed in the morning and evening and are probably inactive at night (Love et al. 2002). Prey includes brachyuran crabs, gammarid amphipods, isopods, and fish (Hueckel and Stayton 1982; Matthews 1990a; Murie 1995; Love et al. 2002). Predators of juveniles and adults include lingcod (*Ophiodon elongatus*), cabezon (*Scorpaenichthys marmoratus*), salmon (*Onchorynchus* spp.), river otters (*Lutra canadensis*), sea lions (*Zalophus californianus*), harbor seals (*Phoca vitulina*), great blue heron (*Ardea herodias*), cormorants (*Phalacrocorax* spp.) and various other marine bird species (Fresh et al. 1981; Jones 2000; Eisenhardt 2001).

REPRODUCTION

Quillback rockfish, like all fish in the Genus *Sebastes*, have internal fertilization and brood their eggs to the larvae stage. Solitary gestating females were recorded resting on the bottom on consolidated reefs in Puget Sound (Palsson, personal communication, September 26, 2003). Mating probably occurs in March in greater Puget Sound (Matthews 1990b), with larval release occurring in May (Matthews 1990a; Love et al. 2002). Following parturition, larval quillback rockfish use the open water habitat in mid water for two months (Moser and Boehlert 1991; Buckley 1997).

LARVAE AND JUVENILES

Larvae at 18 to 25 millimeters total length settle during July through November in shallow nearshore waters and become juvenile fish. These fish are associated with a variety of unconsolidated habitats including soft sediment, cobble, drifting aggregates and beds of macroalgae including bull kelp (*Nereocystis luetkeana*). Young-of-the-year quillback rockfish are widely distributed among a variety of habitat types (Matthews 1990b). In the summer, they use varied habitats including sand with eelgrass or kelp and low-relief reefs. The juvenile quillback rockfish move to high-relief and artificial reefs in the late summer and fall (Matthews 1990b, Stout et al. 2001).

Larval quillback rockfish prey upon zooplankton such as barnacle cyprids, shrimp, calanoid copepods, and larval fish (Hueckel and Stayton 1982, Murie 1995). After settling, the benthic juveniles primarily feed at night on shrimp, invertebrates and small fish associated with macroalgae (Moulton 1977; Washington et al. 1978; Hueckel and Stayton 1982; Murie 1995).

4-26.5 Population Trends

The NOAA Fisheries status review found differing population trends within the three population segments described for this species. Within the Puget Sound proper segment, quillback rockfish were not found by Washington Fish and Wildlife surveys at numerous sites with apparently suitable habitat. In addition, diving surveys showed an 85 percent decrease in the quillback population. Trawl surveys estimated the number of quillback rockfish in 1987 and 1989 at 1,153,000 and 1,055,000, respectively (Stout et al. 2001). In 1991, this value declined to 668,000 and gradually increased to 766,000 in 1995.

Despite data from a variety of survey methods applied by Washington Fish and Wildlife, the population trend for quillback rockfish in the North Puget Sound population segment was not clear. Because of the substantial numbers of quillback rockfish found in these surveys, the NOAA Fisheries status review (Stout et al. 2001) considered the risk of extinction to be no greater than the risk to quillback in the Puget Sound proper population segment.

4-26.6 Assessment of Threats Warranting ESA Protection

The risks to the survival of quillback rockfish were listed by West (1997) as “anthropogenic stressors and natural limiting factors”, and include “over harvesting, loss or degradation of habitat, predation by pinnipeds and fish and pollution-related adverse effects.”

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Habitat for juvenile rockfish could be affected through shoreline development. Sediment flow can be affected by bulkheads or jetties and change sediment characteristics in shallow water where benthic juvenile brown rockfish concentrate. Kelp and eelgrass have been identified as important nearshore habitats for rockfishes and the loss of eelgrass or kelp through dredging or filling may negatively affect juvenile and adult habitat (Palsson et al. 1998). Destruction or degradation of kelp and eelgrass habitats from eutrophication or invasive species may also have negative trophic impacts for this species

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Quillback rockfish are vulnerable to over harvest by recreational fisheries in all population segments. Recreational catches of quillback rockfish continued to decline through 1999 (Stout et al. 2001). Similarly to other rockfish, recreational and commercial take of the largest and oldest fish targets reproductive populations leaving the species particularly sensitive to overfishing. There are no known scientific or educational uses for quillback rockfish.

DISEASE OR PREDATION

While disease is not known to be a significant threat to these species, predation from sea lions (*Zalophus californianus*) and harbor seals (*Phoca vitulina*) may be a factor in decreasing population trends. Due to their protection under the Marine Mammal Protection Act of 1972 pinniped populations have increased and may be placing additional strain on rockfish populations.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Washington Fish and Wildlife manages all of these species and imposes strict catch limits (Palsson et al. 1997). However, while the limits may be inadequate protection due to the fact that rockfish constitute a large percentage of the bycatch for lingcod and salmon fisheries, NOAA Fisheries status review did not cite inadequate regulatory mechanisms as a risk factor.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Demersal rockfish have several traits that may predispose them to accumulation of contaminants. They are carnivorous and may consume prey with bioaccumulated contaminants, and they are long-lived, non-migratory, and reside close to sediments. Available data indicate that quillback rockfish of the Puget Sound proper population segment are exposed to PCBs, PAHs, and mercury at concentrations that could potentially lead to sublethal health effects and reduce the productivity of these fish (West 1997; Stout et al. 2001).

Additional factors affecting this complex rockfish include possible sub-lethal affects from bioaccumulation and concentration of chemical contaminants (West 1997; West and O'Neill 1998); and the possible feminization of male rockfish as a result of human

estrogen/progesterone in the water (West 2004). While some studies have suggested decreases in reproductive success and survival of young rockfish as a result of ocean climate fluctuations such as El Nino and La Nina Southern Oscillation and Pacific Decadal Oscillation (Partnership for Interdisciplinary Studies of Coastal Oceans 2004), the magnitude of this variable in Washington is currently unknown.

4-26.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Quillback rockfish are likely to be affected by activities authorized by Washington DNR within marine nearshore environments. Roadways, bridges, and docks may result in stormwater runoff which may increase concentrations of toxic contaminants including but not limited to hormones, PCBs, heavy metals and petroleum products in both the sediments and water column. Additionally, discharges containing nitrogenous and bacterial waste associated with wastewater treatment, industrial processes or fish hatcheries may decrease water and sediment quality as well as contribute towards eutrophication of the nearshore environment. Net pens associated with fish hatcheries and aquaculture operations may also contribute to the loss of adult habitat from shading and the introduction of disease and parasites. Overwater structures and shoreline modifications may negatively affect habitat by reducing or modifying macroalgae, kelp, and eelgrass habitat. Dredging or disposal of dredged materials has the potential to cover brown rockfish habitat. Furthermore, sediment flow could be changed by bulkheads and jetties and subsequently suffocate habitat.

4-26.8 Species Coverage Recommendation and Justification

It is recommended that quillback rockfish be addressed as an **Evaluation Species** for the following reasons: 1) Although the species is not federally listed, it is listed as a Candidate Species in Washington State and considered vulnerable by the International Union for the Conservation of Nature; 2) Activities authorized by Washington DNR have a "medium" potential to affect quillback rockfish; and 3) Sufficient information is available to assess impacts and to develop conservation measures.

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Draft

4-27 Pacific Cod

4-27.1 Species Name

Gadus macrocephalus

Common Name: Pacific cod

The common and scientific names are valid and correct as they are listed above and currently used by state and federal agencies (Nelson et al. 2004). Additional common names may include “grey cod,” “cod,” “true cod” and “Alaska codfish.”

Initial coverage recommendation: Covered

4-27.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS (NOAA FISHERIES)

Species of Concern

WASHINGTON FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Not Ranked

NATURAL HERITAGE PROGRAM STATE RANK

Not Ranked

4-27.3 Range

Pacific cod occur around the Pacific Rim from the Sea of Japan to Santa Monica Bay, California (Hart 1973; Bakkala et al. 1984; Gustafson et al. 2000). However, the primary concentrations of Pacific cod have historically been in the North Pacific, including the Bering Sea and the waters near northern Japan. This suggests that the Pacific cod populations in Puget Sound are relatively isolated (Gustafson et al. 2000).

The Washington State Department of Fish and Wildlife (Washington Fish and Wildlife) group Puget Sound Pacific cod into the following population segments: North Sound (U.S. waters north of Deception Pass, including the San Juan Islands, Strait of Georgia, and Bellingham Bay); West Sound (west of Admiralty Inlet and Whidbey Island, and the U.S. section of the Strait of Juan de Fuca, including Port Townsend); and South Sound (south of Port Townsend and Admiralty Inlet). A figure representing the distribution of Pacific cod in Washington may be found in Appendix F.

However, NOAA Fisheries Status Review for Pacific cod stated that the distinct population segment delineation is ambiguous and it is not clear if the Puget Sound stock extends to Dixon entrance between Alaska and Canada or farther north into southeast Alaska (Gustafson et al. 2000).

4-27.4 Habitat Use

ADULT

Adult Pacific cod use unconsolidated habitats in the offshore and deep offshore ecosystem of coastal and inland waters. Adults and large juveniles seem to utilize soft bottom habitats associated with clay, sand, or mud (Garison and Miller 1982) and form large concentrations near the bottom at depths of 200 to 500 meters. While Pacific cod occur as deep as 875 meters, they are most common in the 50 to 300 meter range (Hart 1973; NOAA 1990).

In Puget Sound, 50 percent of the male and female Pacific cod reach sexual maturity at 2 to 3 years of age and 45 centimeters total length (NOAA 1990). In coastal waters, males mature when 41 to 53 centimeters and females at 47 to 56 centimeters at 2 to 3 years of age (Westrheim 1996). The maximum observed size for fish in Puget Sound is 91.4 centimeters but adults are usually smaller than 70 centimeters with an average maximum age of 6 years old (Karp 1982). In coastal waters, the average is 8 years old and 83 centimeters (Ketchen 1961).

Adults are carnivorous and opportunistic, feeding at night on whatever prey item is abundant. Dominant prey items vary seasonally with availability and include shrimp, mysids, amphipods, crabs, sand lance, euphausiids, copepods, and small fishes, including Pacific cod juveniles. Predators include toothed whales, pinnipeds, Pacific halibut, salmon sharks, and larger Pacific cod (Hart 1973; NOAA 1990; Palsson 1990).

Pacific cod form large aggregations for feeding and spawning. Pacific cod are considered a non-migratory species but have discrete areas for spawning and feeding, with oceanic fish concentrated at deep spawning areas off the outer and upper slope in fall and winter, and in shallower middle and upper shelf areas in spring and summer for feeding (Westrheim and Taggart 1984).

REPRODUCTION

Pacific cod are oviparous with a single release of eggs and sperm (Sakurai and Hattori 1996). Eggs have been found associated with coarse sand and cobble bottoms, and because most winter concentration areas have bottom sediments consisting of coarse sand

and cobble, it is inferred that Pacific cod preferentially spawn near these bottom types (Palsson 1990). Spawning locations of Pacific cod have been identified in Washington primarily on the basis of wintertime aggregations and have been reported in Agate Passage northwest of Bainbridge Island; Port Townsend Bay; Port Gamble; Dalco Passage near Tacoma; Eliza Island off Bellingham; and off Protection Island and Port Angeles in the Strait of Juan de Fuca (Gustafson et al. 2000). Because of population declines and the age of the data on which Gustafson et al. (2000) based this list, several of these locations may no longer be viable. Spawning aggregations form in January through May with heaviest spawning in February and March (Miller et al. 1978; Bargmann 1980; Wildermuth 1986). Eggs hatch in 8 to 28 days depending on temperature (Gustafson et al. 2000).

LARVAE AND JUVENILES

Pacific cod larvae hatch at about 3 to 4 millimeters with a yolk sac, which is absorbed in about 10 days. Larvae are pelagic and concentrated at the 15 to 30 meter depth zone, settling into nearshore intertidal and shallow subtidal sand and eelgrass habitats at 20 to 25 millimeters (Palsson 1990; Gustafson et al. 2000). While larvae of 2 centimeters length prey upon copepods (Hart 1973), it is not known what larvae feed on between yolk absorption and this size (Gustafson et al. 2000). Larvae are preyed upon by seabirds and pelagic fishes (Hart 1973; NOAA 1990; Palsson 1990).

Juvenile fish move into deeper water as they grow, shifting from shallow sand and eelgrass habitats to unconsolidated habitats in deeper basins (Hart 1973; Karp and Miller 1977; NOAA 1990). The juvenile fish feed on copepods, small shrimps and amphipods at night (Palsson 1990). Juveniles between 6 and 15 centimeters in length prey on euphausiids, amphipods and small fishes (Walters 1984).

4-27.5 Population Trends

Pacific cod stocks have declined throughout their range and little migration between spawning locations has been documented with tagging studies (Westerheim 1982). However, genetic studies indicate that there are no genetically discrete stocks in North American Pacific cod populations (Gustafson et al. 2000).

Assessments of population trends in Washington's inland waters are based on trends in fishery statistics since 1970 (Palsson et al. 1990; Palsson et al. 1997; Gustafson et al. 2000). North of Admiralty Inlet, the catch rate of the commercial bottom trawl fishery varied between 42 and 73 kilograms/hour during the 1970s but was generally stable until 1988 (around 39 kilograms/hour), after which it declined continuously to 12 kilograms/hour (1994). Since 1994, Washington Fish and Wildlife data indicate that catch rates in the bottom trawl fishery were somewhat higher than the low in 1994. In addition, beginning in 1991, the bottom trawl fishery near Port Townsend and Protection Island was closed during the winter to protect Pacific cod and other marine fish (Gustafson et al. 2000).

The South Sound population includes both Port Townsend Bay, where Pacific cod supported bottom trawl and set net fisheries during the winter, and Agate Passage, where

a popular sport fishery harvested Pacific cod in the 1970s and early 1980s (Palsson et al. 1997). Catch rates, estimated catches and effort fluctuated during this period, with the highest catch estimated at 32,800 Pacific cod taken during 8,100 angler trips (4 cod caught per angler trip) during 1981. Estimated catch and effort reached a low of 146 Pacific cod taken during 393 angler trips (0.4 cod caught per angler trip) in 1989 (Palsson 1990).

After 1989, catches and effort remained at low levels and several restrictions were placed on recreational and commercial fisheries for Pacific cod in South Puget Sound. Due to concerns for the status of Pacific cod, commercial fishing for the species was prohibited (Palsson et al. 1997). The Agate Passage area was closed to Pacific cod fishing in 1991 due to concerns over the low numbers and the daily limit for the recreational fishery in Puget Sound south of Admiralty Inlet was reduced from 15 fish to two fish in 1991 and no fish in 1997.

4-27.6 Assessment of Threats Warranting ESA Protection

A NOAA Fisheries status review, Gustafson et al. (2000) concluded that data were insufficient to conduct quantitative analyses of the extinction risks for Pacific cod. Palsson (1990) concluded that the decrease in stock abundance through the 1980s corresponded to a change to a warmer oceanographic regime, and increases in the abundance of pinnipeds and in fishing effort. Overall, it is uncertain which factors, either singly or in combination, may be significantly contributing to the current low abundance of Pacific cod.

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

West (1997) considered the loss or degradation of nearshore nursery habitats as a factor that may decrease survival of juvenile Pacific cod. Small juveniles usually settle into sand and eelgrass habitats, and the areal extent and quality of such habitats have declined in Puget Sound (West 1997).

West (1997) also suggested that declines in the abundance of two primary prey species, Pacific herring and walleye pollock, may have contributed to the decline of Pacific cod in Puget Sound. The effects of contaminants or toxins from phytoplankton blooms ("red tides") on Pacific cod abundance have also not been evaluated.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Current fishing regulations prohibit the commercial and recreational fishing for Pacific cod in Puget Sound (Gustafson et al. 2000). There are no known scientific or educational uses for Pacific cod.

DISEASE OR PREDATION

In limited studies, Pacific cod have not been found to be major components of pinniped diets in Puget Sound (Gustafson et al. 2000). However, the impacts of pinniped predation on Pacific cod have not been evaluated quantitatively. Gustafson et al. (2000) also indicated concern regarding increased releases of yearling Chinook salmon from state hatcheries, which coincided with changes in Pacific cod abundance.

Pacific cod are one of several populations of wild marine fish susceptible to viral haemorrhagic septicaemia (VHS). The infection of susceptible fish species is often lethal, due to the impairment of the osmotic balance, and occurs within a clinical context of oedema and haemorrhages. Virus multiplication in endothelial cells of blood capillaries, leukocytes, haematopoietic tissues and nephron cells, underlies the clinical signs. Disease generally occurs at temperatures between 4 °C and 14 °C. Low water temperatures (1°-5 °C) generally result in an extended course with low daily mortality but high accumulated mortality. Several factors influence susceptibility to VHS. Among each fish species, there is individual variability in susceptibility, and the age of the fish appears to be of some importance - the younger the fish the higher the susceptibility. In highly susceptible fish stocks, however, overt infection is seen in all sizes of fish (OIE 2003).

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Existing regulations related to Pacific Cod are focused on fishery harvest management. If factors contributing to the decline and low current abundance are not related to harvest, existing regulations may be inadequate. Overall, it is not certain which risk factors, either singly or in combination, may be significantly contributing to the current low stock sizes of Pacific cod (Gustafson et al. 2000). Furthermore, if the declines are related to natural, large scale oceanographic and climate changes these factors are certainly beyond the influence of existing regulatory mechanisms.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Pacific cod populations in Puget Sound have remained low, although fishing effort for Pacific cod dropped substantially during the 1980s and has been at extremely low levels during the 1990s. Dorn (1993) and Westrheim (1996) suggested that a warmer oceanographic regime may have unfavorable effects on Pacific cod south of Alaska.

4-27.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Pacific cod are likely to be affected by activities authorized by Washington DNR. Over water structures such as marinas, docks, and wharfs may shade eelgrass or kelp thus reducing available juvenile Pacific cod habitat. Construction and operation of harbors, ports, shipyards, marinas, and ferry terminals could cause habitat reduction and degradation. Transportation projects such as roadways and bridges may result in habitat loss during construction, while stormwater runoff from the structures may increase concentrations of heavy metals, salts and petroleum products that are known to degrade

habitat. Both sewage outfalls and discharges associated with aquaculture may cause localized reductions in sediment and water quality resulting in increased turbidity, eutrophication and decreased habitat quality. Aquaculture operations may also provide a disease vector and may impact Pacific cod spawning and feeding aggregations. Navigation improvements involving dredging, filling or other alteration of the marine nearshore may result in increased sedimentation and/or the direct loss of organisms and habitat.

4-27.8 Species Coverage Recommendation and Justification

It is recommended that Pacific cod be addressed as an **Evaluation Species** for the following reasons: 1) Pacific cod are federally listed as a Species of Concern and as a Candidate in Washington; 2) Washington DNR authorized activities have a “medium” potential to affect Pacific cod; and 3) Sufficient information currently exists to assess impacts and to develop conservation measures.

In response to a petition to list Pacific cod (Wright 1999), NOAA Fisheries initiated a status review (Gustafson et al. 2000) that was completed in 2000. The majority of the Biological Review Team concluded that Pacific cod in the Eastern Pacific were not in danger of extinction at that time (Gustafson et al. 2000).

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<http://www.nwr.noaa.gov/1salmon/salmesa/pubs/petmfish.pdf>.

4-28 Pacific Hake

4-28.1 Species Name

Merluccius productus

Common name(s): Pacific hake, whiting, hake, and Pacific whiting.

Initial coverage recommendation: Covered

4-28.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS (NOAA FISHERIES)

Species of Concern

In the year 2000 NOAA Fisheries completed a status review for Pacific hake and concluded that Pacific hake were not in danger of extinction at that time (Gustafson et al. 2000).

WASHINGTON FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Not Ranked

NATURAL HERITAGE PROGRAM STATE RANK

Not Ranked

4-28.3 Range

Pacific hake occur on the continental shelf and slope from Sanak Island in the western Gulf of Alaska to southern Baja California (Hart 1973; Love 1991). In Washington waters, the fish occur throughout coastal waters, the Strait of Juan de Fuca, and all parts of Puget Sound (Appendix F).

The NOAA Fisheries status review (Gustafson et al. 2000) concluded that Pacific hake in inland Washington waters are part of a separate population segment from coastal

populations that migrate from southern California to southeastern Alaska. The inland Pacific hake were identified as the “Georgia Basin Pacific hake distinct population segment.” The Georgia Basin Pacific hake are not migratory and spend their entire lives in local waters (McFarlane and Beamish 1986).

4-28.4 Habitat Use

In Washington adult Pacific hake use water column habitats in offshore ecosystems of oceanic and inland waters. Eggs and larvae occur in the water column habitat in nearshore and offshore ecosystems in inland waters, but rarely in coastal waters when influenced by El Nino conditions. Puget Sound juveniles use off bottom nearshore habitats.

ADULTS

Adult Pacific hake are pelagic and generally concentrated between 50 and 500 meters deep (Bailey et al. 1982). Both coastal and inland populations use the open water habitat in the offshore ecosystem.

The maximum age of Pacific hake is approximately 20 years, but fish over age 12 are rare (Gustafson et al. 2000). In the Strait of Georgia, female Pacific hake mature at 37 centimeters and 4 to 5 years of age (McFarlane and Beamish 1986) while they mature at 29 centimeters in Puget Sound (Goñi 1988). Females of the coastal stock mature at 3 to 4 years and 34 to 40 centimeters, and nearly all males are mature by age 3 at lengths as small as 28 centimeters. Females grow more rapidly than males after maturity, however growth ceases for both sexes at 10 to 13 years (Bailey et al. 1982). The size-at-age of coastal Pacific hake has been declining since the 1960s (Methot and Dorn 1995; Gustafson et al. 2000). In the early 1990s, age-10 (10 to 11 years old) males and females were 47 and 48 centimeters in length, respectively. In Puget Sound, male Pacific hake rarely exceed a length of 40 centimeters, and females tend to be approximately 4 centimeters longer than males (Gustafson et al. 2000).

Adults are carnivorous, feeding on amphipods, squid, Pacific herring, smelt, crabs, shrimp and sometimes juvenile Pacific hake (Bailey 1981; McFarlane and Beamish 1986). Pacific hake school at depth during the day and move to surface waters at night and disperse to feed (McFarlane and Beamish 1986). Major predators include sablefish (*Anoplopoma fimbria*), albacore (*Thunnus alalunga*), walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), soupfin sharks (*Galeorhinus galeus*), spiny dogfish (*Squalus acanthias*), northern elephant seals (*Mirounga angustirostris*), northern fur seals (*Callorhinus ursinus*), harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), marine birds, and cetaceans (Fiscus 1979; McFarlane and Beamish 1986; Methot and Dorn 1995).

REPRODUCTION

Coastal migratory stocks spawn off Baja California in the winter. After spawning, mature adults begin moving northward and inshore, following food supplies and ocean currents (Gustafson et al. 2000). Pacific hake reach as far north as southern British

Columbia by fall and by late fall begin their return migration to southern spawning grounds and further offshore. These fish may be feeding off the Washington coast near the edge of the continental shelf for 6 to 8 months of the year (Smith 1995).

In Puget Sound, spawning occurs from February through April with a peak in March. Gustafson et al. (2000) and Palsson et al. (1997) reported that spawning aggregations have been recorded in Port Susan, Dabob Bay, and Carr Inlet.

Pacific hake are oviparous with external fertilization, and may spawn more than once per season. Eggs develop in the water column. The eggs of Pacific hake off California are found at depths between 50 and 75 meters over a bottom depth of at least 300 meters. Within Puget Sound, eggs are found at approximately the same depth, but in the bottom 25 meters of the water column over a bottom depth of about 110 meters (Gustafson et al. 2000).

Within Washington large numbers of Pacific hake eggs and larvae only have been found in Port Susan and Saratoga Passage, with small numbers occurring in Hood Canal and near Possession Sound (Gustafson et al. 2000; Palsson et al. 1997). Embryonic development and time to hatching is temperature dependant, occurring in 5 to 6 days at 9° to 10° Celsius and 4 to 5 days at 11° to 13° Celsius (Gustafson et al. 2000).

LARVAE AND JUVENILES

Larvae hatch at 2 to 3 millimeters total length and metamorphose in 3 to 4 months into their juvenile forms. Juveniles range from 35 millimeters to 40 centimeters depending on sex. Juveniles of the coastal migratory population segment remain in the southern waters for feeding and later migrate northwards.

Larvae eat calanoid copepod eggs, nauplii, and adults and are prey to walleye pollock, herring, invertebrates and occasionally adult Pacific hake. Juveniles feed in the water column, preying primarily on euphausiids and are prey to lingcod (*Ophiodon elongatus*), Pacific cod (*Gadus macrocephalus*), and rockfish (*Sebastes* spp.) (Gustafson et al. 2000).

4-28.5 Population Trends

Information on population trends of Pacific hake in Washington waters is dependent on commercial fisheries and Washington Department of Fish and Wildlife (Washington Fish and Wildlife) surveys. The only location at which a commercial fishery and/or surveys have been conducted on a regular basis is Port Susan and adjacent Saratoga Passage, which are also referred to as “Southern Puget Sound” (Palsson et al. 1997; Gustafson et al. 2000). Gustafson et al. (2000) estimated that the Port Susan stock represents 3 to 17 percent of the Georgia Basin Pacific hake population segment.

The winter Pacific hake fishery once accounted for the greatest landings of any groundfish species in Washington. Commercial fisheries on Pacific hake in Port Susan began in 1982 with a high catch of 8,986 metric tons. In 1990, the catch was only 41 metric tons, after which the fishery was suspended (Palsson et al. 1997; Gustafson et al. 2000). Surveys in Port Susan conducted by Washington Fish and Wildlife showed a steady decline in biomass from 1982 with 14,826 metric tons through 2000 with 992

metric tons, an 85 percent decline (Gustafson et al. 2000). In addition, the size composition of the stock showed a marked shift towards smaller fish. Since 1991, the Pacific hake fishery in Puget Sound waters has been suspended due to depressed abundance and small sizes of Pacific hake.

4-28.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

The NOAA Fisheries status review (Gustafson et al. 2000) did not cite habitat loss or degradation as a risk factor contributing to the extinction of Puget Sound Pacific hake. A decline in nearshore kelp and eelgrass beds may only indirectly affect Pacific hake through changes in detritus-based trophic webs. West (1997) speculated that juvenile survival could be reduced through loss or degradation of nearshore nursery habitats.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

There are no commercial or sport fisheries on the Port Susan stock of Pacific hake at this time. The decline in this population is likely in part a result of the intense commercial fishery up to 1991 (Gustafson et al 2000; Palsson et al. 1997). There are no known scientific or educational uses for Pacific hake.

DISEASE OR PREDATION

Wright's (1999) petition to list Pacific hake and the Endangered Species Act status review (Gustafson et al. 2000) highlight predation by pinniped marine mammals as the greatest threat to Pacific hake. In Puget Sound, there is a threat from increasing populations of predators such as harbor seals (*Phoca vitulina*) and California sea lions (*Zalophus californianus*). Pacific hake are estimated to comprise around 32 percent of the sea lion diet and 40 percent of the harbor seal diet near Port Susan (Schmitt et al. 1995; Gustafson et al. 2000). Palsson et al. (1998) observed that marine mammals appear to be limiting the population of Pacific hake in Port Susan (Palsson et al. 1998).

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Existing regulations prohibiting commercial fishing for Pacific hake in Puget Sound appear to be adequate and Gustafson et al. (2000) did not cite inadequate regulations as a factor in their risk assessment.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Decadal climate oscillations and El Nino events may be affecting the reproductive success and survival of Pacific hake. The effect of warm, El Nino years is evident in the coastal migratory population as spawning occurs farther north in those years. In addition, the Port Susan population apparently has changed more than the Canadian portion of the Georgia Basin population segment (Gustafson et al. 2000). It is possible that warm

environmental conditions have caused the Port Susan area to be relatively less favorable for Pacific hake spawning than the Canadian portion of the Strait of Georgia. Some of the Port Susan population may have migrated to Canadian waters, or perhaps there has been less movement from Canadian waters than in previous years.

Anthropogenic changes in river flow patterns and increased turbidity could also cause changes in the ecosystem that trigger changes in planktonic trophic webs. These changes in turn could be adverse to Pacific hake (Gustafson et al. 2000). Insufficient studies are available to determine if there have been impacts from anthropogenic sources of toxic chemicals.

4-28.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Pacific hake are likely to be affected by activities authorized by Washington DNR within marine nearshore environments. Roadways, bridges, and docks may result in stormwater runoff which may increase concentrations of toxic contaminants including but not limited to hormones, PCBs, heavy metals and petroleum products in both the sediments and water column. Additionally, discharges containing nitrogenous and bacterial waste associated with wastewater treatment, industrial processes or fish hatcheries may decrease water and sediment quality as well as contribute towards eutrophication of the nearshore environment. Net pens associated with fish hatcheries and aquaculture operations may also contribute to the loss of adult habitat from shading and the introduction of disease and parasites. Overwater structures and shoreline modifications may negatively affect habitat by reducing or modifying macroalgae, kelp, and eelgrass habitat. Dredging or disposal of dredged materials along with bulkheads and jetties may alter sediment flow from freshwater systems that may disrupt planktonic food web assemblages.

4-28.8 Species Coverage Recommendation and Justification

It is recommended that Pacific hake be addressed as an **Evaluation Species** for the following reasons: 1) The species is listed as both a federal and state Species of Concern; 2) Washington DNR activities have a "medium" potential to affect Pacific hake; and 3) Although sufficient information is available to assess impacts, it may not be sufficient to develop conservation measures.

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4-29 Pacific Herring

4-29.1 Species Name

Clupea pallasii

Common Name: Pacific herring

The common name, Pacific herring, is approved and listed by the American Fisheries Society (Nelson et al. 2004). Pacific herring were formerly known under the same scientific name as the “Atlantic herring” (*Clupea harengus*), but were recognized as a distinct species in 1986 based on a study of biochemical genetics. Pacific herring is referred to as Atlantic herring in older publications and in local literature as an invalid composite name (*Clupea harengus pallasii*).

Initial coverage recommendation: Covered

4-29.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not Listed

All Puget Sound Pacific herring were proposed for listing as Threatened or Endangered in 1999, with NOAA Fisheries determining that listing under the Endangered Species Act was not warranted in 2001 (66 CFR 2001). A petition for listing the Pacific herring stock that spawns along the Cherry Point shoreline (north of the city of Bellingham in Puget Sound) was submitted and rejected in January 2004 (69 CFR 153 (2004)), with a supplemental petition for the Cherry Point stock submitted in May of 2004. In June 2005, NOAA Fisheries determined that Cherry Point herring “doesn’t qualify for Endangered Species Act protection because it does not meet the standard for a species under the law”.

WASHINGTON FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Not Ranked

NATURAL HERITAGE PROGRAM STATE RANK

Not Ranked

4-29.3 Range

The geographic range of Pacific herring includes most of the waters over continental shelves in the Northeast Pacific Ocean from Baja California, Mexico, to the Bering Sea and northeast to the Beaufort Sea. The species also ranges along the Asian coast from the Arctic Ocean to Japan (Washington Fish and Wildlife 1997). Within Washington, Pacific herring occur as adults in all marine waters and use both state and privately owned shorelines for spawning (Appendix F). Information collected on Pacific herring spawning does not distinguish between private or state-owned beaches.

Puget Sound (those waters south of Port Townsend and east of Deception Pass) stocks apparently do not migrate and all life stages remain in Puget Sound waters (Lassuy 1989; Washington Fish and Wildlife 1997; Gao et al. 2001; Stout et al. 2001). However, stocks spawning at Cherry Point and in Discovery Bay may migrate to the waters offshore of the West Coast of Vancouver Island (EVS 1999; Gao et al. 2001; Stout et al. 2001).

Washington Fish and Wildlife recognizes 18 distinct herring stocks in Washington waters east of Cape Flattery and two on the outer coast (Willapa Bay and Grays Harbor) based on spawning grounds (Lemberg et al. 1997; Washington Fish and Wildlife 1997; Stout et al. 2001; O'Toole, Personal communication. March 3, 2005). Stout et al. (2001), concluded that a "distinct population segment" (DPS) of the Pacific Coast herring population consisted of the herring within the Georgia Basin. This DPS includes all Puget Sound, Cherry Point, Discovery Bay (Strait of Juan de Fuca), and Strait of Georgia (British Columbia) spawning stocks. In addition, on the outer coast of Washington, Pacific herring spawn has been documented in Willapa Bay and Grays Harbor and reported from the Columbia River estuary (Lemberg et al. 1997; Stout et al. 2001; O'Toole, Personal communication. March 3, 2005).

4-29.4 Habitat Use

Herring are primary and secondary consumers in all their habitats and are a critical "keystone species" with trophic links to a large number of other marine biota. Adult and larval Pacific herring feed and depend on phytoplankton and zooplankton, especially crustaceans (e.g., copepods and decapod and barnacle larvae) and a variety of other prey items such as protozoans, diatoms, molluscan larvae, euphausiids, and larval fish (Lassuy 1989; Washington Fish and Wildlife 1997).

In addition, a number of secondary and tertiary consumers in marine food webs depend on herring. This species is taken as prey by marine mammals, seabirds, other fishes, and marine invertebrates (e.g., jelly fish) (Lassuy 1989). Environment Canada (1998) estimated that herring comprise 71 percent of lingcod (*Ophiodon elongatus*), 62 percent of Chinook salmon (*Oncorhynchus tshawytscha*), 58 percent of coho salmon

(*Oncorhynchus kisutch*), 53 percent of Pacific halibut (*Hippoglossus stenolepis*), 42 percent of Pacific cod (*Gadus macrocephalus*), 32 percent of Pacific hake (*Merluccius productus*), 18 percent of sablefish (*Anoplopoma fimbria*), and 12 percent of spiny dogfish (*Squalus acanthias*) diets off the West Coast of Vancouver Island. Pacific herring also comprise an estimated 6 percent of the diet of California sea lions in Puget Sound and 32 percent of harbor seal diets (Stout et al. 2001).

Herring are also prey for a variety of marine birds including loons (*Gavia* spp.), grebes (*Podiceps* spp.), cormorants (*Phalacrocorax* spp.), great-blue heron (*Ardea herodias*), common mergansers (*Mergus merganser*), terns (*Sterna* and *Chlidonias* spp.), the common murre (*Uria aalge*), the pigeon guillemot (*Cephus columba*), the rhinoceros auklet (*Cerorhinca monocerata*), and the tufted puffin (*Fratercula cirrhata*). While estimates of herring consumption by these birds are not available (Stout et al. 2001), marine birds are also known to consume herring eggs after deposition on marine vegetation.

ADULTS

Adult herring use the water column habitat in nearshore and offshore ecosystems in both coastal and inland waters (Stout et al. 2001). Spawning adults use unconsolidated nearshore habitats in the form of intertidal and shallow subtidal beaches vegetated with eelgrass and macroalgae on which eggs are deposited. Herring deposit transparent, adhesive eggs on intertidal and shallow subtidal (generally above minus 3 meters mean lower low water) eelgrass and marine algae. Marine birds feed heavily on herring eggs and adult forms may comprise a vital food source for some migratory birds such as surf scoter (*Melanitta perspicillata*) and white-winged scoters (*Melanitta fusca*). While most Washington State herring stocks spawn from late January through early April (Washington Department of Fish and Wildlife 1997), the Cherry Point stock spawns from early April through early June.

LARVAE

Larvae are planktonic and use the shallow waters (less than 10 to 20 meters) over the intertidal and shallow subtidal zones while growing. Following metamorphosis, juvenile herring use the same ecosystem and habitats as adults.

4-29.5 Population Trends

Petitions to list herring as Threatened or Endangered have included all Puget Sound stocks (1999) or focused on the Cherry Point stocks (2004). However, because the first petition for listing was rejected and no decision on the recent petitions has been publicized at the time of this writing, Pacific herring in Washington are treated as a single distinct population segment. Additional information is provided for the Cherry Point stock because of the recent listing petitions. Washington Fish and Wildlife classifies Pacific herring populations in Washington into five status categories (Lemberg et al. 1997):

- Healthy – recent two year mean abundance above or within 10 percent of the 20 year mean.
- Moderately Healthy – recent two year mean abundance within 30 percent of the 20 year mean and/or with high dependence on recruitment.
- Depressed – recent abundance well below the long-term mean, but not so low that permanent damage to the population is likely (i.e., recruitment failure).
- Critical – abundance low enough that permanent damage to population is likely or has already occurred.
- Extinct – no longer can be found in a formerly and consistently utilized spawning ground.
- Unknown – insufficient assessment data to identify stock status with confidence.

Table 1.1
Status of Inland Herring Populations (east of Cape Flattery) of Puget Sound (From Stout et al. 2001).

Stock Name/Location	Stock Status		
	1996	1998	2000
Squaxin Pass	Moderately Healthy	Depressed	Healthy
Quartermaster Harbor	Healthy	Healthy	Healthy
Port Orchard/Port Madison	Depressed	Depressed	Healthy
South Hood Canal	Unknown	Moderately healthy	Healthy
Quilcene Bay	Healthy	Healthy	Healthy
Port Gamble	Healthy	Depressed	Healthy
Kilisut Harbor	Unknown	Moderately Healthy	Healthy
Port Susan	Depressed	Healthy	Moderately Healthy
Holmes Harbor	Unknown	Healthy	Depressed
Skagit Bay	Healthy	Moderately Healthy	Moderately Healthy
Fidalgo Bay	Moderately Healthy	Healthy	Healthy
Samish – Portage Bay	Healthy	Healthy	Healthy
Interior San Juan Islands	Unknown	Unknown	Depressed
Northwest San Juan Islands	Unknown	Depressed	Unknown
Semiahmoo Bay	Healthy	Depressed	Depressed
Cherry Point	Depressed	Critical	Critical
Discovery Bay	Critical	Critical	Critical
Dungeness Bay	Healthy	Healthy	Healthy

The Cherry Point population was one of the largest Puget Sound stocks of Pacific herring, and its late spawning time is unique for Puget Sound (Bargmann 1998, 2001; Lemberg et al. 1997; Stout et al. 2001). This stock has declined substantially since the 1970s when populations had attained a relatively high abundance. Landis et al. (2004) suggests this high abundance may be due to favorable oceanic conditions, three consecutive years of excellent age 0+ (0 to 1 year old) class survival and recruitment and a potential influx of fish from other regional stocks. The biomass continued to decline until 2001 when an increase began continuing through 2004 as shown by the following data¹:

Year	1999	2000	2001	2002	2003	2004
Tons of spawners	1,266	808	1,241	1,330	1,611	1,734

Washington Fish and Wildlife's Forage Fish Management Plan reported that estimates of natural mortality rates in the Cherry Point Pacific herring stock increased from less than 0.4 between 1976 and 1980 to more than 0.6 between 1990 and 1995 (Bargmann 1998; Stout et al. 2001). During the same period, the number of age groups comprising the bulk of the populations decreased from five to two or three. While herring formerly lived to ages exceeding 10 years, fish older than 6 years are now rare (Bargmann 1998). A combination of reduced recruitment of 3-year-old herring and increased non-fishery related losses of older fish appear to be the primary causes of the Cherry Point declines and may also be impacting other Puget Sound populations (Stout et al. 2001; EVS 1999; Landis et al. 2004).

It should be noted that the Cherry Point Pacific herring stock was historically not the most abundant in Puget Sound. During the expansion of the herring fishery in Washington State between 1890 and 1935, the Cherry Point herring stock was not considered among the five most productive stocks in the Puget Sound region, with other Puget Sound stocks including Holmes Harbor, Hood Canal and Bremerton-Keyport yielding the highest catches (Markiewicz and Landis 2003). As a result, it is possible that the Cherry Point stocks' abundance during the 1970s may have either been anomalous or an indication that the stock experiences significant natural abundance fluctuations.

4-29.6 Assessment of Threats Warranting ESA Protection

When interpreting the behavior of Pacific herring distinct population segments and evaluating their status, the nature of the responses of Pacific herring to environmental stress must be considered. Pacific herring belong to the family Clupeidae, a family of small pelagic fish species (e.g. Atlantic herring, sardines, anchovies, shad, menhaden) that are broadly distributed in coastal waters around the globe and are sensitive to broad scale changes in environmental conditions. Temporal and spatial fluctuations in biomass resulting from shifts in environmental conditions can be rapid, large and persistent, often

¹ Spawning survey data by G. Bargmann, Washington Fish and Wildlife Marine Fish, supplied to the Cherry Point Technical Work Group through emails from 1999 through 2004.

lasting for decades or more. The life history strategy and population structure of clupeoids has evolved in response to environmental variability and are characterized by periodic substantial fluctuations in abundance. The greatest risks to future Cherry Point and other Pacific herring stocks' survival include predation, adverse climatic conditions, loss or degradation of habitat, disease and parasites, and pollution-related effects (Stout et al. 2001; EVS 1999; Landis et al. 2004).

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

As stated by EVS (1999), Stout et al. (2001) and Landis et al. (2004), loss or modification of habitat poses the greatest ecological risk to Cherry Point herring, and by extrapolation, to other stocks of Pacific herring in Washington. Loss and modification of habitat can occur through physical disruption of spawning grounds, including shading of vegetation, construction of nearshore structures that affect sediment movement, or by degradation of the open water habitat by pollution.

The near shore, shallow-water spawning habitat causes Pacific herring to be particularly vulnerable to exposure to contaminants from such sources as oil spills, urban and agriculture runoff and chronic air pollution (Stout et al. 2001). As the most vulnerable and critical life stage, herring eggs can be exposed to contaminants during embryonic development. Because of their importance to the food web, there is concern that if herring are exposed to toxic contaminants and accumulate them, much of the local food web could be affected (Stout et al. 2001; O'Neill and West 2001). O'Neill and West (2001) documented that Pacific herring from the central and southern Puget Sound basins had higher body burdens of polychlorinated biphenyls (PCBs) than fish from northern Puget Sound and the Strait of Georgia. In addition, low hexachlorobenzene (HCB) concentrations were observed for all stocks but were significantly lower for the Cherry Point stock.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Commercial fisheries on Pacific herring are closely co-managed by Washington Fish and Wildlife and Tribal agencies. No commercial fishery is allowed on the Cherry Point or coastal stocks. Existing fisheries consist only of a commercial sport bait and recreational fishery in South and Central Puget Sound, which utilizes juvenile fish (Bargmann 1998). Stout et al. (2001) considered these and other small fisheries as minor and taking fewer fish than consumed by natural predators.

DISEASE OR PREDATION

An increased incidence of parasitism, disease, and larval deformities in Puget Sound Pacific herring and especially in the Cherry Point stock has been observed in recent studies (e.g., Hershberger and Kocan 1999, 2000; Hershberger et al. 2002; Hershberger, Personal communication. March 3, 2005). These factors may contribute to the decline or slow recovery of Puget Sound stocks, especially the Cherry Point Pacific herring. In 2000, Hershberger detected a prevalence of *Ichthyophonus* infections in 17 to 55 percent of prespawn Pacific herring in 10 different Puget Sound stocks. The prevalence of high-level infections (i.e., observable gross signs of disease) was generally low (0 to 5 percent) with the exception of the Cherry Point stock, where 31 percent of the fish demonstrated

infections and 15 percent demonstrated high-level infections (Hershberger, Personal communication. March 3, 2005).

Herring are intensely preyed upon by a wide variety of predators as discussed previously. Further increases in these predators (e.g., pinnipeds) could cause subsequent declines in Pacific herring populations.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Stout et al. (1999) did not cite the inadequacy of regulatory mechanisms as a risk factor. Indeed, because of the intense public attention to the Cherry Point Pacific herring stock, management and conservation of Pacific herring in Puget Sound is probably receiving more attention than in the past.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Despite the presence of baseline data describing the abundance and age structure of the Cherry Point herring prior to their documented decline, it is difficult to show that changes are due to a single or combination of specific perturbations or conditions. Potential causes of decline that cannot be excluded as potential causative factors include: changes in oceanic conditions associated with the Pacific Decadal Oscillation; introduction of new diseases to a previously naïve stock; potential reduced abundance of prey items for adults within feeding areas; or reduced viability of offspring due to anthropogenic impacts to spawning areas. Observed population trends that may have resulted from these causes include: increasing natural mortality of Cherry Point herring, low weight at hatch of Cherry Point offspring, loss of older individuals from the population, reduction of geographic extent of spawning, and decreased overall population abundance and spawning escapement. Overall, it is uncertain which factors, either singly or in combination, may be significantly contributing to the decline and current low abundance of Cherry Point herring.

4-29.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Pacific herring in Puget Sound are particularly vulnerable to nearshore and onshore activities authorized by Washington DNR that affect intertidal and shallow subtidal spawning habitats. The Discovery Bay, Cherry Point, and coastal Pacific herring stocks probably migrate out of Washington waters for juvenile rearing and adult feeding. Thus, while few Washington DNR authorized activities could directly affect adult populations, activities authorized within or adjacent to the spawning grounds could have impacts. Because juveniles and adults use Puget Sound water column habitats throughout the year, they are vulnerable to activities that degrade marine water quality and affect planktonic food sources. Roadways, bridges, and docks may result in stormwater runoff which may increase concentrations of toxic contaminants including but not limited to hormones, PCBs, heavy metals and petroleum products in both the sediments and water column. Additionally, discharges containing nitrogenous and bacterial waste associated with wastewater treatment, industrial processes or fish hatcheries may decrease water and sediment quality as well as contribute towards eutrophication of the nearshore

environment. Net pens associated with fish hatcheries and aquaculture operations may also contribute to the loss of adult habitat from shading and the introduction of disease and parasites. Overwater structures and shoreline modifications may negatively affect habitat by reducing or modifying macroalgae, kelp, and eelgrass habitat, thereby reducing available spawning habitat. Dredging or disposal of dredged materials along with bulkheads and jetties may alter sediment flow from freshwater systems that may disrupt planktonic food web assemblages.

4-29.8 Species Coverage Recommendation and Justification

It is recommended that Pacific herring and the Puget Sound and Cherry Point spawning stocks be addressed as an **Evaluation Species** for the following reasons: 1) Although the species is not federally listed as a Threatened, Endangered or a Species of Concern it is listed as a state Candidate. Furthermore, the Cherry Point Pacific herring spawning stock is under formal status review by NOAA Fisheries as of March 2005; 2) Activities authorized by Washington DNR have a "medium" potential to Pacific herring; and 3) Sufficient information is available to assess impacts and to develop conservation measures.

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4-30 Walleye Pollock

4-30.1 Species Name

Theragra chalcogramma

Common Name: Walleye pollock

The common and scientific names are valid and correct as they are listed above and currently used by state and federal agencies (Nelson et al. 2004). Additional common names may include "Pacific pollock," "Alaska or Alaskan Pollock," "scrapcod" and "bigeye pollock."

Initial coverage recommendation: Evaluation

4-30.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not Listed

In response to a petition (Wright 1999) to list walleye pollock, NOAA Fisheries initiated a status review that was completed in 2000 and resulted in the conclusion that walleye pollock in the Eastern Pacific were not in danger of extinction at that time (Gustafson et al. 2000).

WASHINGTON FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Not Ranked

NATURAL HERITAGE PROGRAM STATE RANK

Not Ranked

4-30.3 Range

Walleye pollock occur on the continental shelf and slope from the Sea of Japan to Central California (Hart 1973; Saunders et al. 1989). Gustafson et al. (2000) defined one distinct population segment in the northeastern Pacific Ocean, the Lower Boreal Eastern Pacific population. This segment includes walleye pollock from Puget Sound to Southeast Alaska and offshore into the Northeast Pacific Ocean.

Within Washington waters, walleye pollock occur throughout Puget Sound, the San Juan Archipelago, and the lower Strait of Georgia (Miller and Borton 1980) (Appendix F). The Washington Department of Fish and Wildlife recognizes two stocks of walleye pollock in Puget Sound, North Sound and South Sound with the dividing line at Port Townsend. Washington Fish and Wildlife differentiates the stocks by spawning location, growth rates, and other biological characteristics (Palsson et al. 1997). Walleye pollock in the southern stock are on the extreme southern end of their global distribution (Palsson et al. 1997; Gustafson et al. 2000). Specific records on bathymetric range and occurrence in Washington coastal waters were not found.

4-30.4 Habitat Use

ADULTS

Adult walleye pollock are semi-demersal, using openwater and unconsolidated habitats in the nearshore, offshore, and deep offshore ecosystems in both coastal and inland waters. The depth range of walleye pollock is surface to 366 meters (Hart 1973), with the largest abundance occurring between 40 and 120 meters (Gustafson et al. 2000).

Walleye pollock are carnivorous, feeding on euphausiids, copepods, amphipods and small fishes, including age-0 (0 to 1 year old) walleye pollock (Livingston 1989, 1993). Dominant prey items vary seasonally with availability. Predators include lingcod (*Ophiodon elongatus*), salmon (*Onchorynchus* spp.), river otters (*Lutra canadensis*), sea lions (*Zalophus californianus*), harbor seals (*Phoca vitulina*), great blue heron (*Ardea herodias*), cormorants (*Phalacrocorax* spp.) (Pitcher 1980; Lowry et al. 1996).

REPRODUCTION

In Puget Sound, male and female walleye pollock reach sexual maturity at age 1 and older and between 25 to 38 centimeters total length (Gustafson et al. 2000), with fish in coastal waters maturing later at 2 to 3 years old and 40 centimeters (Saunders et al. 1989). The maximum age for fish in Puget Sound is estimated to be 10 years with a maximum size of 91.4 centimeters, and 8 years and 74 centimeters total length in coastal waters (Saunders et al. 1989).

Most pollock populations spawn at predictable times in the same locations year after year, usually in sea valleys, canyons, or indentations in the outer margin of the continental shelf. In Puget Sound, they spawn in deep-water bays (Gustafson et al. 2000)

forming spawning aggregations during February through April at depths of 110 to 145 meters.

After pairing, the female releases batches of eggs over a short period of time that are fertilized in the water column (Sakurai 1982). Eggs are pelagic occurring in water column habitats above 60 meters in nearshore and offshore ecosystems (Saunders et al. 1989; Gustafson et al. 2000). Incubation is dependent on temperature and varies from 10 days at 10° Celsius to nearly 30 days at 2° Celsius.

LARVAE AND JUVENILES

Early-stage larvae grow about 0.10 to 0.20 millimeter per day and metamorphose into juveniles at a length of about 18 millimeter (Gustafson et al. 2000). In the first year, juveniles grow up to 1 millimeter per day, reaching 80 to 100 millimeters in length in six months and 120 to 140 millimeters by the end of the first year.

Larvae tend to aggregate in patches under the influence of currents, geographical formations, and availability of prey. Larvae and small juveniles are found down to depths of 60 meters, with juveniles in North Puget Sound and the Strait of Georgia, juveniles moving quickly into nearshore nursery areas in May and June. Fish between 21 and 87 millimeters in length have been found associated with eelgrass habitat (Gustafson et al. 2000), while larger juveniles occupy the water column and also use unconsolidated gravel and cobble seafloor habitats (Miller et al. 1976; Sogard and Olla 1993). As the juveniles grow, they migrate to deeper water (Quinnell and Schmitt 1991).

Small juveniles rise to the surface at night to feed, primarily preying on copepod nauplii (Garrison and Miller 1982), and are prey to euphausiids, amphipods and small fishes (Canino et al. 1991; Bailey et al. 1999). Larger juveniles feed in the water column, preying on euphausiids, copepods, decapod larvae and larvaceans (Brodeur 1998; Bailey et al. 1999) and are preyed upon by seabirds, sea lions (*Zalophus californianus*), harbor seals (*Phoca vitulina*) and adult walleye pollock (Bailey et al. 1989; Hunt et al. 1996).

4-30.5 Population Trends

A sport fishery near Tacoma once made walleye pollock the most common bottomfish harvested in Puget Sound recreational fisheries. Catches in southern Puget Sound exceeded 181 metric tons per year from 1977 to 1986 (Gustafson et al. 2000). Catch rates in the recreational fishery exceeded 1.3 fish per angler trip in 1978 and 1979 after which the rate declined to 0.5 fish per trip in 1986 and to negligible levels by 1991 (Palsson et al. 1997; Gustafson et al. 2000). Due to concerns about the status of the population, Washington Fish and Wildlife reduced the daily catch limit from 15 fish to 5 in 1992 and to zero in 1997.

North Puget Sound walleye pollock are caught in a commercial trawl fishery, which apparently exploits a spawning aggregation in the Strait of Georgia extending into Washington waters from Canada (Gustafson et al. 2000). Pedersen and DiDonato (1982) identified a walleye pollock trawl fishery that operated from December to April with a peak in March to April at an average depth of 128 meters along the international border

southwest of Point Roberts. Catch between 1970 and 1998 was low with two peak periods, and by 1992 to 1994, catch was almost zero (Palsson et al. 1997).

Washington Fish and Wildlife bottom trawl surveys showed a decline in the Southeast Strait of Georgia-Bellingham area from approximately 34 million fish in 1987 to 1.5 million in 1997 (Gustafson et al. 2000). More recent data have not been published yet and no data is available for a coastal population off Washington. However, a commercial fishery was recently allowed because of the occurrence of “large quantities every 5 to 7 years” (68 CFR 18 (2003)).

4-30.6 Assessment of Threats Warranting ESA Protection

Wright’s 1999 petition to list walleye pollock and the Endangered Species Act status review (Gustafson et al. 2000) discusses several activities that threaten walleye pollock or their essential habitat.

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Water column habitats and planktonic trophic webs supporting adult and juvenile fish and their reproductive products could be affected by pollutants from oil spills, wastewater and storm water discharge, and untreated ballast water release and by introduced species (Washington Fish and Wildlife 1998). In addition, they could be affected by the loss of nearshore juvenile habitats from shoreline modification and overwater structures.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Trawl surveys and commercial and recreational landings of walleye pollock reached zero in all areas in 1998. This decline was probably due in part to fishing, but also may be attributable to biological factors such as climate change causing a shift in distribution. (Washington Fish and Wildlife 1998; Gustafson 2000). As the population declined it is possible that catch rates exceeded maximum sustainable yields for the population and contributed to the overall rate of population decline.

DISEASE OR PREDATION

Walleye pollock was the number one prey item for harbor seals (*Phoca vitulina*) in the Gulf of Alaska (Pitcher 1980) and increases in pinniped populations in Puget Sound could be a threat (Washington Fish and Wildlife 1998). The recovery of pinniped populations may reduce the ability of this population to recover and may have contributed to its decline.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Existing harvest regulatory mechanisms are apparently adequate. Washington Fish and Wildlife reduced the catch limit for walleye pollock from 15 per trip to zero in 1997 for

the South Puget Sound stock (Gustafson et al. 2000). However, regulatory mechanisms may be inadequate where pollution and marine mammal predation are concerned.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Decadal climate oscillations may be affecting population abundance. Walleye pollock in Puget Sound are at the southern limit of abundance. Warm water events such as El Nino could affect their distribution (Washington Fish and Wildlife 1998; Gustafson et al. 2000).

4-30.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Walleye pollock are likely to be affected by activities authorized by Washington DNR within marine nearshore environments. Roadways, bridges, and docks may result in stormwater runoff which may increase concentrations of toxic contaminants including but not limited to hormones, PCBs, heavy metals and petroleum products in both the sediments and water column. Additionally, discharges containing nitrogenous and bacterial waste associated with wastewater treatment, industrial processes or fish hatcheries may decrease water quality as well as contribute towards eutrophication of the nearshore environment. These discharges will directly affect the growth and development of pelagic embryos, larvae, and juveniles. Net pens associated with fish hatcheries and aquaculture operations may also contribute to the loss of adult habitat from shading and the introduction of disease and parasites. Overwater structures and shoreline modifications may negatively affect habitat by reducing or modifying macroalgae, kelp, and eelgrass habitat, thereby reducing available juvenile pollock habitat. Dredging or disposal of dredged materials along with bulkheads and jetties may alter sediment flow from freshwater systems that may disrupt planktonic food web assemblages.

4-30.8 Species Coverage Recommendation and Justification

It is recommended that walleye pollock be addressed as an **Evaluation Species** for the following reasons: 1) Although the species is not federally listed as a Threatened, Endangered or a Species of Concern it is listed as a state Candidate; 2) Activities authorized by Washington DNR have a "medium" potential to walleye pollock; and 3) Although sufficient information is available to assess impacts, it may not be sufficient to develop conservation measures.

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4-31 Widow Rockfish

4-31.1 Species Name

Sebastes entomelas

Common Name: Widow rockfish

Initial coverage recommendation: Evaluation

4-31.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not listed

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Not Ranked

NATURAL HERITAGE PROGRAM STATE RANK

Not Ranked

4-31.3 Range

Widow rockfish range from Kodiak Island, Alaska to northern Baja California, Mexico (Love et al. 2002; Hart 1973). While they are most abundant from northern British Columbia to northern California at depths of 150 to 200 meters, they have been found in large schools in shallower waters (approximately 25 meters) near seamounts. In Washington Widow rockfish are found along the outer coast and are a pelagic schooling species most common in depths from 50 to 100 meters (Tagart 1987). Although records indicate widow rockfish have been reported in the San Juan Islands, they remain undocumented in other areas in Puget Sound (Miller and Borton 1980), suggesting that this species may be found only in coastal and offshore areas. Information regarding the geographic distribution of widow rockfish for all life stages is incomplete, therefore no species distribution map is presented for this species.

4-31.4 Habitat Use

ADULT

Adult widow rockfish are known to be pelagic, forming loose schools in the water column over rocky consolidated habitats, and often co-occurring with yellowtail and dusky rockfishes (Tagart 1987). Widow rockfish school at night and disperse during the day, behavior that is thought to be unique among rockfish (Wilkins 1987).

This species are opportunistic predators that feed during the day on salps, fish (specifically myctophids and Pacific hake), caridean shrimp and euphausiids (Adams 1987). They have also been known to feed on amphipods, squid and anchovies (Love et al. 2002).

Widow rockfish can live to 60 years (Love et al. 1990), with fish in northern latitudes (Oregon and Washington) growing faster than those in California (Love et al. 2002). Widow rockfish are dimorphic (Lenarz and Wyllie Echeverria 1991) with sexual maturity for males occurring at 4 years (33 centimeters in length), with females maturing at 7 years (38 centimeters in length) on average (Barss and Wyllie Echeverria 1987).

REPRODUCTION

Mating occurs once a year, generally in the fall (Barss and Wyllie Echeverria 1987) with females producing from 100,000 to more than 1 million cream-colored eggs (Love et al. 2002). Females store sperm for up to a month while their eggs fully develop, at which time fertilization occurs. Widow rockfish, like other *Sebastes* species, are ovoviviparous and produce live young, although no additional nutritive material is supplied by the parent (Barss and Wyllie Echeverria 1987). Embryos develop for about one month before parturition, the timing of which varies by region (Matarese et al. 1989).

Parturition occurs between December and April, with fish in Oregon and British Columbia (northern regions) releasing larvae later than those in California (Barss and Wyllie Echeverria 1987; Matarese et al. 1989). Given these studies, it is likely that fish in Washington release larvae in the late winter, though no data on parturition rates for the Washington coast or Puget Sound presently exist.

LARVAE AND JUVENILES

Larvae are about 5 millimeters in length at parturition (Love et al. 2002). Although larvae of most rockfish species can be found in the upper portion of the water column in the springtime, difficulty in identifying individual species has led to a lack of information regarding early life histories for many species (Matarese et al. 1989).

Widow rockfish juveniles are thought to remain neritic longer than other rockfish species spending up to 5 months in the plankton and experiencing rapid growth and development (Love et al. 2002; Matarese et al. 1989). After settling, at about 5 to 7 centimeters, juveniles occupy rocky areas in nearshore waters and are often associated with kelp, macro-algae, and manmade structures (Love et al. 2002). They can be found in or just outside of kelp forests and feed mainly on calanoid copepods and subadult euphausiids (Reilly et al. 1992).

4-31.5 Population Trends

Since the early 1980s, widow rockfish, along with several other species, have experienced dramatic population declines as a result of being sought by recreational and commercial fisheries. Because widow rockfish are pelagic schooling fish, they are easily targeted in commercial fisheries (using mid-water trawls), where catches of 100 percent widow rockfish are not uncommon (Tagart 1987). In addition to being a targeted species, widow rockfish made up about 50 percent of the rockfish incidental catch taken in the 1980s from bottom trawls (Tagart 1987). By the mid-1980s their population was a fraction of peak levels and catch limits were set in place (He et al. 2003a). Widow rockfish are often caught with yellowtail rockfish, Pacific ocean perch, Pacific whiting, bocaccio, canary rockfish and sharpchin rockfish.

Widow rockfish were declared overfished by NOAA Fisheries in 2001, and the Pacific Fishery Management Council has established a rebuilding plan (Williams et al. 2000; He et al. 2003b).

4-31.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Widow rockfish generally inhabit offshore neritic habitats, which are not at a high risk of destruction or modification. Although this species is often associated with consolidated substrate for diel migration, they are one of the more pelagic rockfish species and are frequently found in the water column. Widow rockfish are caught by the commercial fishery in mid-water trawls, which have minimal impacts on benthic habitats. Despite the lack of direct impact to consolidated habitats, the species is at risk from direct harvest.

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

The widow rockfish population was designated overfished by NOAA fisheries in 2001. A rebuilding plan is currently imposed and commercial catch is tightly regulated, as a result of drastic reductions in population size incurred during the “boom and bust” fishery of the 1970s and 1980s.

DISEASE OR PREDATION

Neither disease nor predation is known to be a significant threat to this species.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

Although existing harvest regulations for widow rockfish and related species have decreased the commercial harvest of these species, past over-utilization has resulted in depressed populations. As of 2003, widow rockfish were estimated to be slightly less

than 25 percent of their unfished spawning potential (He et al. 2003b). Current management efforts may be aiding in the rebuilding of the stock, but given the loss of large, fecund fish and a period of poor recruitment, possibly due to climate, the rebound will not be rapid.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Recreational and commercial take, especially of the largest and oldest fish, are the most significant concerns for rockfish.

4-31.7 Assessment of Potential Effects from Washington DNR Authorized Activities

As an offshore neritic species that does not commonly occur in Puget Sound, the widow rockfish has a lower potential for adverse impacts from activities authorized by Washington DNR than other rockfish species. However, nearshore activities as port development and construction of overwater structures that remove or modify kelp forests may impact juvenile widow rockfish habitat.

4-31.8 Species Coverage Recommendation and Justification

Widow rockfish should be considered an **Evaluation Species** because: 1) Although the species is not federally listed it is a Candidate Species in Washington; 2) Activities authorized by Washington DNR have a “low” potential to widow rockfish; and 3) Insufficient information is available regarding the distribution of adult and juvenile widow rockfish to assess impacts and to develop conservation measures.

4-31.9 References

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4-32 Yelloweye Rockfish

4-32.1 Species Name

Sebastes ruberrimus

Common Name: Yelloweye rockfish

Initial coverage recommendation: Evaluation

4-32.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not listed

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Not Ranked

NATURAL HERITAGE PROGRAM STATE RANK

Not Ranked

4-32.3 Range

Yelloweye rockfish range from the Unalaska Island in the Aleutian Islands of Alaska to Baja California, Mexico (Hart 1973; Love et al. 2002) and are most abundant from central California to southeast Alaska. This species is found in water from 40 to 550 meters in depth, though they are most common from 100 to 150 meters (Eschmeyer and Herald 1983; Love et al. 2002).

In Washington, Yelloweye rockfish are found offshore along the outer coast and are rare in Puget Sound (Love et al. 2002). While data for Washington populations are quite limited (Wallace 2001), in 1982 Garrison and Miller stated that yelloweye rockfish were common on consolidated rocky habitats in coastal waters and Puget Sound. Information

regarding the geographic distribution of yelloweye rockfish for all life stages is incomplete, therefore no species distribution map is presented for this species.

4-32.4 Habitat Use

ADULT

Yelloweye rockfish occupy complex rock and wall habitats and are often associated with boulder fields, broken rock, overhangs and crevices (Yoklavich et al. 2000; Jagielo et al. 2003). They are sedentary demersal fish, generally found on or just above rocky substrates (Love et al. 2002; Yamanaka et al. 2002), and are thought to possess strong site fidelity because of their sedentary nature (Methot et al. 2002). Yelloweye rockfish are opportunistic predators, feeding mainly on other rockfish, flatfish, herring, sand lance, crab and shrimp (Love et al. 2002; Yamanaka et al. 2002).

Yelloweye are among the largest and longest lived of rockfish and Andrews et al. (2002) used otolith measurements to confirm ages of more than 100 years for several yelloweye rockfish specimens. This species is slow-growing and late-maturing, reaching sexual maturity at a length of about 45 centimeters and 20 years of age (Barss 1989). Males and females mature at about the same age, and there is no evidence that sexual maturity occurs at different ages within their geographic ranges (Methot et al. 2002). Sexual dimorphism is absent, with males and females approximately the same size at a given age (Lenarz and Wyllie Echeverria 1991).

REPRODUCTION

Mating occurs once a year, generally in the winter, and while timing and fecundity is not well known (Garrison and Miller 1982), females are thought to produce between 1 and 3 million eggs per season (Love et al. 2002).

(Garrison and Miller 1982). Females store sperm for 4 to 6 weeks while their eggs develop and once the eggs are fertilized, the embryos develop for about 5 weeks before parturition (Wourms 1991). Like other *Sebastes* species, yelloweye rockfish are ovoviviparous and produce live young. Parturition occurs offshore between February and September, peaking at different times depending upon location in the range (Love et al. 2002); off British Columbia, the peak occurs in May or June (Westrheim 1975).

LARVAE AND JUVENILES

Few data exist for the early life-history stages of yelloweye rockfish (Love et al. 2002). Larvae are thought to be released offshore and are found in the upper mixed zone of the ocean, where they are believed to be dispersed by physical transport processes (Yamanaka et al. 2002).

Yelloweye rockfish juveniles settle in shallow (50 to 100 meters) nearshore and offshore rocky areas (Yamanaka et al. 2002), probably during their first year of life, but exact timing is unknown. Juveniles have been observed occupying areas of high relief and have also been associated with off-shore oil platforms in southern California (Love et al. 2002).

Juvenile yelloweye rockfish likely eat plankton, such as crustaceans, and fish eggs, though few diet data exist for early life-history stages of this species. Although rockfish typically move to deeper habitats as they age, given their strong site fidelity and sedentary nature, it is currently unknown if yelloweye rockfish follow the same pattern (Yamanaka et al. 2002).

4-32.5 Population Trends

Despite not maturing until age 20 (Wallace 2001), yelloweye rockfish recruit to the fishery at age three which has dramatic impacts on the reproductive potential of the stock (i.e., many fish are removed by the fishery prior to reaching sexual maturation). Because of their life-history characteristics (long-lived, late-maturing, slow-growing) and habitat fidelity, they are particularly vulnerable to overfishing, and stocks could take years to recover (Leaman 1991).

These rockfish occupy habitats that are inherently difficult to survey with conventional methods such as trawls, therefore, it is likely that many of the population estimates that exist for yelloweye rockfish are biased, incomplete or otherwise inaccurate (Yamanaka et al. 2000; Jagielo et al. 2003). For example, Jagielo et al. (2003) observed yelloweye rockfish at much higher densities in Oregon and California than on the Washington coast. While one possible explanation is that the Washington fishery has long been subjected to heavy fishing pressure, it is more likely that the survey design didn't capture specific substrate features utilized by yelloweye rockfish (Jagiello 2003). This sampling bias may lead to inaccurate stock assessments (Methot et al. 2002). Submersibles and acoustic surveys are becoming more common for stock assessments.

Throughout the history of the yelloweye rockfish fishery, trawl landings are believed to be small, as these rockfish occupy habitats that are inaccessible to trawl gear (Methot et al. 2002). However, yelloweye rockfish are the target of long-line fisheries, including a targeted commercial long-line fishery in the Gulf of Alaska (Johnson et al. 2003), and they are often caught as bycatch in the commercial Pacific halibut long-line fishery (Yamanaka et al. 2000). Additionally, they have been highly valued in the recreational hook-and-line fishery on the north Pacific coast for many years, both for the quality of their flesh and their bright color. Their site fidelity and association with specific habitat types have made them easy targets for fishermen, who are able to locate bottom features by using modern fishing equipment, such as depth finders and global positioning systems.

Yelloweye rockfish were declared overfished by the National Oceanic and Atmospheric Administration (NOAA) Fisheries in 2002 and a rebuilding plan is being drafted by NOAA Fisheries and the Pacific Fishery Management Council. In addition, both Washington and Oregon Fish and Wildlife have prohibited the retention of yelloweye rockfish in recreational fishing areas, and some groundfish management plans stress utilizing either marine protected areas, "no-take" designations or regional closures for rebuilding the stock (Palsson et al. 1998). While these actions may aid in rebuilding this sedentary stock, it is likely that it will take decades for the fishery to recover, (Yamanka et al. 2000).

4-32.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Yelloweye rockfish inhabit offshore and nearshore rocky, consolidated habitats, which are not at high risk of destruction or modification.

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

NOAA Fisheries has declared yelloweye rockfish overfished, and a rebuilding plan is in place. State agencies, such as Washington Fish and Wildlife and Oregon Fish and Wildlife, have prohibited retention of yelloweye rockfish in the recreational fishery. However, the inability of rockfish species, like yelloweye, to survive catch-and-release fishing (they are subject to swim bladder embolism upon surfacing) has made the reduction of incidental loss difficult. Their high market value has also contributed to continued harvest, specifically from commercial long-line and recreational fisheries.

DISEASE OR PREDATION

Neither disease nor predation has been identified as a significant threat to the species.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

While the species has been formally declared overfished, no commercial fishery regulations are specific for yelloweye, in part because trawl fisheries cannot access yelloweye rockfish habitat (Methot et al. 2002). As yelloweye rockfish continue to be targeted in both commercial long-line and recreational fisheries, as well as captured as bycatch in other long-line fisheries, existing regulations may be inadequate to protect this species.

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Recreational and commercial take, especially of the largest, oldest, most fecund fish, are the most significant concerns for rockfish. Additionally, the lack of data regarding the specific ecology of individual rockfish species, larval and juvenile ecology, food habits or how oceanic conditions might affect recruitment may complicate conservation efforts (Love et al. 2002; Harvey 2005).

4-32.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Because yelloweye rockfish have strong site fidelity and are sedentary (Berkeley et al. 2004, Palsson et al. 1998), they are especially vulnerable to habitat disturbance and loss. While this species is mostly found offshore, activities authorized by Washington DNR

that reduce or modify macroalgae, kelp and eelgrass habitat may impact juveniles of this species.

4-32.8 Species Coverage Recommendation and Justification

Yelloweye rockfish should be considered an **Evaluation Species** because: 1) While the species is not federally listed, NOAA Fisheries has declared the species overfished and Washington state considers yelloweye rockfish a Candidate Species; 2) Activities authorized by Washington DNR have a “medium” potential to yelloweye rockfish; and 3) Insufficient information regarding early life history, fecundity and distribution of yelloweye rockfish in Washington exists to assess impacts and develop conservation measures.

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4-33 Yellowtail Rockfish

4-33.1 Species Name

Sebastes flavidus

Common Name: Yellowtail rockfish

Initial coverage recommendation: Evaluation

4-33.2 Status and Rank

See glossary for listing and ranking definitions and criteria.

FEDERAL STATUS

Not listed

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE STATUS

Candidate

NATURAL HERITAGE PROGRAM GLOBAL RANK

Not ranked

NATURAL HERITAGE PROGRAM STATE RANK

Not ranked

4-33.3 Range

Yellowtail rockfish are found from Unalaska Island, Alaska, to San Miguel Island in southern California (Hart 1973; Love et al. 2002) and are most common from Oregon to British Columbia in water 90 to 200 meters deep (Lai et al. 2003).

In Washington yellowtail rockfish are found along the outer coast and although they were once common at shallow depths (12 to 25 meters) in Puget Sound, the Strait of Juan de Fuca and around the San Juan Islands (Garrison and Miller 1982), their current distribution is poorly understood. Information regarding the geographic distribution of yellowtail for all life stages is incomplete, therefore no species distribution map is presented for this species.

4-33.4 Habitat Use

ADULT

Adult yellowtail rockfish are benthopelagic, forming loose schools in the water column over consolidated habitat, similar to widow rockfish. They tend to be associated with high-relief substrate, although they have been observed over cobble and mud habitats as well (Love et al. 2002; Jagielo et al. 2003). Yellowtail co-occur with canary, black, widow, silvergray and other species of rockfish (Tagart 1987).

Tagging studies have been conducted to assess yellowtail movement patterns (Matthews and Barker 1983; Pearcy 1992). Pearcy's study (1992), which used acoustic tags, showed that most fish remained local or homed back to the capture site (up to 4 kilometers). Matthews and Barker (1983) showed that fish (mostly juveniles) ranged hundreds of kilometers, migrating from Puget Sound to the coast of Washington. Yellowtail rockfish have also been observed to make rapid vertical migrations, although no pattern in migratory behavior could be discerned (Percy 1992; Love et al. 2002).

Yellowtail rockfish can live to more than 60 years, reaching a maximum size of about 65 centimeters in length at approximately 15 years of age (Lai et al. 2003), with fish in northern latitudes (Oregon and Washington) growing faster than those in California (Love et al. 2002). As is common with rockfish, sexual maturity occurs at different ages and sizes for males and females. Males mature at a slightly smaller size (approximately 40 centimeters) than females (approximately 42 centimeters) (Garrison and Miller 1982). Yellowtail rockfish recruit to the fishery at an age of 4 years (Lai et al. 2003).

Juvenile and adult yellowtail rockfish are opportunistic predators, feeding on water-column and benthic-prey items (Reilley et al. 1992), as well as euphausiids and fish, specifically myctophids (Rosenthal et al. 1988).

REPRODUCTION

Mating occurs once a year, generally in the fall, with the females retaining pockets of sperm until eggs have fully developed (Eldridge et al. 1991; Love et al. 2002). Females produce from 50,000 to more than three million eggs per year (Love et al. 2002) and like other *Sebastes* species, yellowtail rockfish are viviparous, producing live young. Eldridge et al. (2002) showed the gestation period of this species to average 29.2 days, including 6 days of larval incubation before parturition.

Parturition occurs January through March in north Pacific waters (Garrison and Miller 1982), with Eldridge et al. (1991) observing that all parturition occurs during the night and that females stop feeding prior to releasing larvae.

LARVAE AND JUVENILES

Yellowtail rockfish larvae are about 4.5 millimeters in length at parturition (Love et al. 2002). They have been found more than 260 kilometers offshore and are known to have an extended pelagic juvenile stage (Garrison and Miller 1982; Love et al. 2002).

Juvenile yellowtail rockfish remain in the plankton for up to 4 months or until they are about 4.5 centimeters in length (Love et al. 2002), foraging on copepods and euphausiids, including their eggs (Reilly et al. 1992). Juveniles, in particular, are thought to be highly motile (Matthews and Baker 1983; Love et al. 2002). After settling, at about 5 to 7 centimeters in length (as small as 2.5 centimeters in California waters), yellowtail rockfish juveniles occupy consolidated habitats in nearshore waters, associated often with kelp or algae (Love et al. 2002). They have been seen schooling over rocky reefs and will form small groups in cracks and crevices (Garrison and Miller 1982; Johnson et al. 2003).

4-33.5 Population Trends

Although harvested since the 1940s by midwater and bottom trawls, yellowtail rockfish and several other species have experienced population declines since the 1970s from being targeted by recreational and commercial fisheries. In the 1970s, yellowtail (along with widow rockfish) were the main target of fishermen from Oregon and Washington. Yellowtail rockfish have been reported as bycatch in the Pacific whiting fishery and in the salmon trolling and halibut long-lining fisheries in Canada.

Because yellowtail rockfish co-occur with species that are strictly regulated because of very low population levels (e.g., canary rockfish), fishing pressure on this species has relaxed in recent years, affording the species some level of protection (Lai et al. 2003). The biomass estimated in 2000 is believed to be about 50 percent of the unfished biomass estimated in 1967 (Lai et al. 2003).

Current population assessments for Puget Sound are unavailable, but Washington Fish and Wildlife has plans to conduct surveys. Moulton (1977) saw large schools in northern Puget Sound at the time of his survey, though the distribution and abundance of these fish today are unknown.

4-33.6 Assessment of Threats Warranting ESA Protection

DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

Yellowtail rockfish inhabit offshore neritic habitats, which are not at high risk of destruction or modification. Although are often associated with consolidated, high-relief substrate, they are one of the more pelagic rockfish species, found in the water column. Despite the lack of direct impact to consolidated habitats, the species is affected by direct harvest.

OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Although the yellowtail rockfish population has declined by 50 percent in the last 40 years (Lai et al. 2003), it has not been designated overfished (this designation is given to stocks that are less than 25 percent of their unfished levels). Yellowtail rockfish are an important species in the commercial groundfish fishery; however, catch limits on co-occurring species have led to decreased harvest pressure for this species.

DISEASE OR PREDATION

Neither disease nor predation has been identified as significant threats to the species.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

The Pacific Fishery Management Council manages the yellowtail rockfish fishery in the United States. This fishery saw substantial growth in the 1970s and 1980s; however, as stocks of other species, such as canary rockfish, began to collapse in the 1990s, fishing pressure on yellowtail rockfish declined. Current population assessments for this species in Puget Sound are unavailable; therefore, the adequacy of regulatory mechanisms can not be assessed. It is likely that yellowtail rockfish populations have population trends similar to other rockfish species and that conservation measures should be implemented (Palsson et al. 1998).

OTHER FACTORS AFFECTING CONTINUED EXISTENCE

Recreational and commercial take, especially of the largest and oldest fish, are the most significant concerns for rockfish (Parker et al. 2000). The effects of climate, variable oceanic conditions and other man-made impacts, such as pollution, have not been well documented, though there is some evidence that climate change impacts recruitment (Parker et al. 2000; Harvey 2005).

4-33.7 Assessment of Potential Effects from Washington DNR Authorized Activities

Although nearshore activities that remove or modify kelp forests, such as port development and construction of overwater structures may be detrimental to yellowtail rockfish populations, the overall impact from activities authorized by Washington DNR is thought to be minimal. Because juveniles are more commonly found in shallow nearshore areas than adults they are most susceptible to shore-based changes

4-33.8 Species Coverage Recommendation and Justification

Yellowtail rockfish should be addressed as an **Evaluation Species** because: 1) Although the species is not federally listed, it is a Candidate Species within the State of

Washington; 2) Activities authorized by Washington DNR have a “medium” potential to impact yellowtail rockfish; and 3) Insufficient information is available regarding the distribution of yellowtail rockfish in Washington to assess impacts and to develop conservation measures.

4-33.9 References

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